MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL LXIX. FEBRUARY 12, 1909. No. 4

ANNUAL GENERAL MEETING.

H. F. NEWALL, Esq., M.A., F.R.S., PRESIDENT, in the Chair.

The Report of the Auditors of the Treasurer's accounts for the year 1908 was read, and is given on p. 234.

The Annual Report of the Council was partly read; see pp. 231 to 323.

The Address was delivered by the President, who gave an account of the grounds on which the Gold Medal had been awarded to Dr. Oskar Backlund for his researches on Encke's Comet. The Medal was then handed to Dr. Backlund.

Continuing his address, the President announced that the Jackson-Gwilt Gift and Bronze Medal had been awarded to Mr. P. J. Melotte for his discovery of the eighth satellite of Jupiter. The Medal and Gift were then handed to Mr. Melotte (see pp. 324 to 332).

The President then delivered a further Address, which is given on pp. 332 to 344.

The following motion which had been recommended by the Council, and of which due notice had been given to the Fellows, was put to the Meeting and carried :—

"That in the foot-note to Bye-Law 41 the word *October* be substituted for the word *July*."

The foot-note, therefore, now stands :—

"It is at the option of the Council, at their discretion, to insert or omit, year by year, the month of October in the list of Ordinary Meetings."

The President having appointed the Scrutineers, the Society proceeded to the ballot for Officers and Council for the ensuing year. The names of those elected are given on p. 345.

The thanks of the Meeting were given to the retiring Members of Council, and also to the Auditors of the Treasurer's accounts and to the Scrutineers of the ballot.

Samuel Ernest Loxton, Cannock, Staffordshire;
John Mastin, F.L.S., F.C.S., etc., Woodleigh House, Totley Brook, near Sheffield;
Philibert J. Melotte, Royal Observatory, Greenwich, S.E.; and
Arthur James Potts, 36 Pentland Road, Edgbaston, Birmingham,

were balloted for and duly elected Fellows of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended:—

G. A. Hemsalech, 6 Place de la Sorbonne, Paris (proposed by Prof. A. Schuster);
Griffith Parry Jenkins, Hamilton, Ontario, Canada (proposed by A. A. Rambaut);
Richard Henry Norman, M.D., B.S., etc., 26 Canonbury Park South, N. (proposed by G. F. Hardy);
Harry Edwin Wood, M.Sc., Chief Assistant, Government Observatory, Johannesburg, South Africa (proposed by R. T. A. Innes); and
Julien Péridier, Ingénieur, 9 rue Gimelli, Toulon, France (proposed by Col. E. E. Markwick).

Report of the Council to the Eighty-ninth Annual General Meeting of the Society.

The following table shows the progress and present state of the Society:—

	Patron	Honorary Members	Fellows		Associates	Total
			Compounders	Annual Subscribers		
1907 December 31	1	2	259	417	44	723
Since elected	...	...	+3	+33	+5	...
Deceased	...	...	−6	−13	−2	...
Resigned	...	...	...	−5	...	...
Since compounded	...	...	+5	−5	...	...
Removed	...	...	...	−16	...	...
1908 December 31	1	2	261	411	47	722

Major Hills' Account as Treasurer of the Royal

RECEIVED.

	£ s. d.	£ s. d.
Balances, 1907 December 31 :—		
At Bankers', as per Pass-book	386 7 8	
Cheques not credited till 1908	27 2 0	
In hand of Assistant Secretary on Account of Turnor and Horrox Fund	6 2 6	
In hand of Assistant Secretary on Petty Cash Account	8 1 1	
		427 13 3
Dividends :—		
£1,250 Metropolitan 3-per-cent. Stock ...	35 12 8	
£1,964 12*s.* 7*d.* Swansea Corporation 3½-per-cent. Stock	65 6 6	
£3,400 East Indian Railway 3-per-cent. Debenture Stock	96 18 0	
£3,500 London and North-Western Railway 3-per-cent. Debenture Stock	99 15 0	
£4,000 Midland Railway 2½-per-cent. Debenture Stock	95 0 0	
£500 Lancashire and Yorkshire Railway 3-per-cent. Consolidated Preference Stock ...	14 5 0	
£1,860 Gas Light and Coke Co. 3-per-cent. Debenture Stock	53 0 2	
£1,650 Commercial Gas Co. 3-per-cent. Debenture Stock	47 0 6	
		506 17 10
Interest on money on deposit at Bankers'		4 3 4
Received on account of Subscriptions :—		
Arrears	197 8 0	
Annual Contributions for 1908	621 12 0	
,, ,, in advance	8 8 0	
Admission Fees	71 8 0	
First Contributions	53 11 0	
		952 7 0
Composition Fees...		143 17 0
Sales of Publications, &c. :—		
At Williams & Norgate's, 1907	23 0 9	
At Society's Rooms, 1908	87 2 2	
Sales of Photographs, 1908	26 8 6	
		136 11 5
Contribution from the Secretary of State for India of one-third the cost of Pogson's Memoir on Variable Stars	47 19 6	
Do. do. from Mr. C. L. Brook	47 19 6	
		95 19 0
Income Tax refunded by Commissioners of Inland Revenue		26 4 4
		£2,293 13 2

Examined and found correct, 1909 Jan. 5.

F. W. Levander.
A. E. Conrady.

Astronomical Society, from 1908 *January* 1 *to December* 31.

PAID.

	£	s.	d.	£	s.	d.
Assistant Secretary: Salary	250	0	0			
,, ,, Editing Society's Publications	50	0	0			
Clerk's Salary	75	0	0			
				375	0	0
House Duty	2	12	6			
Fire and Servants' Insurance	9	12	6			
				12	5	0
Printing, &c.:—						
Monthly Notices	385	15	9			
Photo-Engraving for do.	13	1	0			
Memoirs, Vol. 57, Parts 3 and 4, and Vol. 59, Part 1	118	9	6			
Appendix to *Memoirs*, Vol. 57, and Plates for do.	18	18	0			
Memoirs, Vol. 58 (Pogson's Observations) £120 8 8						
Drawing and Engraving Charts for do. 23 9 8						
	143	18	4			
Miscellaneous Printing	28	8	9			
				708	11	4
Reproduction of Photographs for sale				27	16	2
Cataloguing Astronomical Literature for the International Catalogue of Scientific Literature ...				30	0	0
Turnor and Horrox Fund, purchase of books for Library	10	1	7			
Binding books in Library	34	14	1			
Cleaning books in Library	13	10	0			
				58	5	8
Expenses of Meetings	16	16	0			
Lantern expenses	6	15	7			
Time Signal: rental of wire	5	0	0			
				28	11	7
Postage and Telegrams	82	4	3			
Carriage of Parcels	3	15	0			
Stationery	7	14	6			
Sundry do. and Office expenses	11	16	8			
				105	10	5
Repairing and putting in order Standard Scale ...				2	0	0
House expenses: Allowance and sundry expenses	63	6	10			
Coal and Gas	47	7	10			
Electric Light expenses	20	9	8			
Fittings, Repairs, and Decorating	14	2	8			
Sundries	4	18	7			
				150	5	7
Contribution towards cost of measuring a Geodetic Arc in Uganda				50	0	0
Purchase of £300 London and North-Western Railway 3-per-cent. Debenture Stock, including Commission				284	6	6
Bankers' deductions on cheques				0	2	7
Balances, 1908 December 31:—						
At Bankers', as per Pass-book	453	16	11			
Cheques not credited till 1909	4	4	3			
In hand of Assistant Secretary on account of Turnor and Horrox Fund	1	0	11			
In hand of Assistant Secretary on Petty Cash Account	1	16	3			
				460	18	4
				£2,293	13	2

Report of the Auditors.

We have examined the Treasurer's account of receipts and expenditure for the year 1908, and have found and certified the same to be correct. The cash in hand on December 31, 1908, including the balance at the bankers', etc., amounted to £460 18*s.* 4*d.*

The funded property of the Society has been increased by the purchase of £300 London and North-Western Railway 3-per-cent. Debenture Stock.

The books, instruments, and other effects in the possession of the Society have been examined, and they appear to be in a satisfactory condition.

We have laid on the table a list of the names of those Fellows who are in arrear for sums due at the last Annual General Meeting of the Society, with the amount due against each Fellow's name.

(*Signed*) F. W. Levander.
A. E. Conrady.

12*th. February* 1909.

Gifts to the General Funds of the Society.

In 1836 John Lee, Esq., LL.D., gave the Advowson of the living of Hartwell; in 1844 he gave the Advowson of the living of Stone. In 1879 these Advowsons were repurchased by his heir, Edward Lee, Esq., for £700.

The Lawson Bequest (1856): Henry Lawson, Esq., bequeathed to the Society the sum of £200, free of legacy duty.

The Carrington Bequest (1876): R. C. Carrington, Esq., F.R.S., bequeathed to the Society £2,000 Consols. This was sold in 1899, and stands now in £1,881 14*s.* London and North-Western Railway 3-per-cent. Debenture Stock.

The Lambert Bequest (1877): C. J. Lambert, Esq., presented to the Society the sum of £500, free of legacy duty, being part of a sum of money bequeathed by his father, Charles Lambert, Esq., for scientific purposes.

The McClean Bequest (1905): Frank McClean, Esq., LL.D., F.R.S., bequeathed to the Society the sum of £2,000, free of legacy duty. This now stands in £1,871 1*s.* 6*d.* Swansea Corporation 3½-per-cent. Stock.

The Farrar Bequest (1906): The Rev. A. S. Farrar, D.D., bequeathed to the Society the sum of £100, free of legacy duty. This now stands in £93 11*s.* 1*d.* Swansea Corporation 3½-per-cent. Stock.

One-third of the cost of the publication of Pogson's Memoir on Variable Stars was contributed by H.M. Secretary of State for India, and one-third by Mr. C. L. Brook.

Trust Funds.

The Lee and Janson Fund: In 1834 John Lee, Esq., LL.D., gave £100, and in 1876 T. C. Janson, Esq., bequeathed £200, the interest to be given to the widow or orphan of a deceased Fellow. These amounts now stand in £334 10*s.* 9*d.* East Indian Railway 3-per-cent. Debenture Stock.

The Turnor Fund and the Horrox Memorial Fund: In 1853 the Rev. Charles Turnor, M.A., bequeathed a sum of £500, which now stands in £464 18*s.* East Indian Railway 3-per-cent. Debenture Stock. In 1876 the Society received a sum of £38 15*s.*, the unexpended balance of a fund collected for the purpose of erecting a memorial in Westminster Abbey to Jeremiah Horrox: to this the Society added a sum of £55 15*s.*, and the whole now stands in £103 6*s.* East Indian Railway 3-per-cent. Debenture Stock. The interest on these funds is to be used in the purchase of books for the Library.

The Hannah Jackson (née Gwilt) Fund: In 1861 Mrs. Hannah Jackson (*née* Gwilt) gave £300 Consols, which now stands in £309 18*s.* 6*d.* East Indian Railway 3-per-cent. Debenture Stock; the interest to be given in medals or other awards in accordance with the terms of the Trust.

Assets and Present Property of the Society, 1909 January 1.

	£	*s.*	*d.*	£	*s.*	*d.*
Balances, 1908 December 31 :—						
At Bankers', as per Pass-book	453	16	11			
Cheques not credited till 1909	4	4	3			
In hand of Assistant Secretary on account of Turnor and Horrox Fund	1	0	11			
In hand of Assistant Secretary on Petty Cash Account	1	16	3			
				460	18	4
Due on account of Subscriptions :—						
1 Contribution of 7 years' standing	14	14	0			
1 ,, 6 ,, ,, ...	12	12	0			
3 ,, 4 ,, ,, ...	25	4	0			
15 ,, 3 ,, ,, ...	94	10	0			
29 ,, 2 ,, ,, ...	121	16	0			
52 ,, 1 ,, ,, ...	109	4	0			
3 Admission Fees and First Contributions ...	9	9	0			
	387	9	0			
Less Subscriptions paid in advance	8	8	0			
				379	1	0
Due for Photographs sold				1	1	0
Due for Publications				12	1	0
Due from Williams & Norgate for Publications sold in 1908 ...				25	10	9

£3,400 East Indian Railway 3-per-cent. Debenture Stock, including the Turnor Fund, the Horrox Memorial Fund, the Lee and Janson Fund, and the Hannah Jackson (*née* Gwilt) Fund.

£3,500 London and North-Western Railway 3-per-cent. Debenture Stock (including the Carrington Bequest).

£4,000 Midland Railway 2½-per-cent. Debenture Stock.

£500 Lancashire and Yorkshire Railway 3-per-cent. Consolidated Preference Stock.

£1,860 Gas Light and Coke Co. 3-per-cent. Debenture Stock.

£1,650 Commercial Gas Co. 3-per-cent. Debenture Stock.

£1,964 12*s.* 7*d.* Swansea Corporation 3½-per-cent. Stock (the McClean and Farrar Bequests).

Astronomical and other Manuscripts, Books, Prints, Photographs, and Instruments.

Furniture, &c.

Stock of Publications of the Society.

Three Gold Medals.

Celestial Photographs.

The following is a list of reproductions of Celestial Photographs published by the Royal Astronomical Society for sale to the Fellows:—

R.A.S. Ref. No.	Subject.	Photographed by
1	Total Solar Eclipse, 1889 January 1	W. H. Pickering
2	Total Solar Eclipse, 1893 April 16	J. M. Schaeberle
3	Total Solar Eclipse, 1886 August 29	A. Schuster
4	Nebulæ in the *Pleiades*	Isaac Roberts
5	Nebula M 74 *Piscium* (N.G.C. 628)	Isaac Roberts
6	Great Nebula in *Orion*	Isaac Roberts
7	Milky Way near M 11	E. E. Barnard
8	Milky Way near Cluster in *Perseus*	E. E. Barnard
9	Comet 1893 IV. (Brooks), 1893 October 21	E. E. Barnard
10	Comet 1892 I. (Swift), 1892 April 7	E. E. Barnard
11	Nebula about η *Argus*	David Gill
12	Portion of Moon (Hyginus-Albategnius)	Loewy and Puiseux
13	Comet 1893 IV. (Brooks), 1893 October 22	E. E. Barnard
14	Comet 1893 IV. (Brooks), 1893 October 20	E. E. Barnard
15	Comet 1893 IV. (Brooks), 1893 November 10	E. E. Barnard
16	Comet 1892 I. (Swift), 1892 April 26	E. E. Barnard
17	Comet 1892 III. (Holmes), 1892 November 10	E. E. Barnard
18	Comet 1892 I. (Swift), 1892 April 18	E. E. Barnard
19	Portion of Moon (Alps, Apennines, &c.)	Loewy and Puiseux
20	Nebula in *Andromeda*	Isaac Roberts

R.A.S. Ref. No.	Subject.	Photographed by
21	*Jupiter*, 1892 September 26	Lick Observatory
22	Cluster M 13 *Herculis* (N.G.C. 6205)	W. E. Wilson
23	Total Solar Eclipse, 1893 April 16 (5 sec.)	J. Kearney
24	Total Solar Eclipse, 1893 April 16 (20 sec.)	J. Kearney
25	The Moon (Age 7d. 3h.)	Lick Observatory
26	The Moon (Age 12d. 6½h.)	Lick Observatory
27	The Moon (Age 16d. 18h.)	Lick Observatory
28	The Moon (Age 23d. 8h.)	Lick Observatory
29	The Sun, 1892 February 13	Roy. Obs., Greenwich
30	The Sun, 1892 July 8	Roy. Obs., Greenwich
31	Portion of Moon (Region of Maginus)	Loewy and Puiseux
32	The Moon (Age 14d. 1h.)	Lick Observatory
33	Portion of Moon (Ptolemæus, &c.)	Lick Observatory
34	Portion of Moon (Mare Serenitatis)	Lick Observatory
35	Portion of Moon (Clavius, Licetus, &c.)	Lick Observatory
36	Portion of Moon (Regiomontanus, &c.)	Lick Observatory
37	Portion of Moon (Tycho, Thebit, &c.)	Lick Observatory
38	Portion of Moon (Theophilus, &c.)	Lick Observatory
39	Total Solar Eclipse, 1896 August 9 (3 sec.)	S. Kostinsky
40	Total Solar Eclipse, 1896 August 9 (26 sec.)	A. Hansky
41	Cluster M 56 *Lyræ* (N.G.C. 6779)	
42	Nebulæ M 81, 82 *Ursæ Majoris* (N.G.C. 3031, 3034)	
43	Cluster M 56 *Lyræ* (N.G.C. 6779) (enlarged)	
44	Solar Corona, 1871 December 12, Baikul	H. Davis
45	Solar Corona, 1875 April 6, Siam	Lockyer and Schuster
46	Solar Corona, 1878 July 29, Wyoming	W. Harkness
47	Solar Corona, 1882 May 17, Egypt	Abney and Schuster
48	Solar Corona, 1883 May 6, Caroline Island	Lawrance and Woods
49	Solar Corona, 1885 Sept. 9, Wellington, N.Z.	Radford
50	Solar Corona, 1886 August 29, Grenada, W.I.	A. Schuster
51	Solar Corona, 1887 August 19, Japan	M. Sugiyama
52	Solar Corona, 1889 January 1, California	W. H. Pickering
53	Solar Corona, 1889 December 22, Cayenne	J. M. Schaeberle
54	Solar Corona, 1893 April 16, Fundium	J. Kearney
55	Solar Corona, 1893 April 16, Brazil	A. Taylor
56	Great Nebula in *Orion*	W. E. Wilson
57	Dumb-bell Nebula, *Vulpecula* (N.G.C. 6853)	W. E. Wilson
58	Spiral Nebula, *Canes Venatici* (N.G.C. 5194–5)	W. E. Wilson
59	Ditto (enlarged)	W. E. Wilson
60	Annular Nebula, *Lyra* (N.G.C. 6720)	W. E. Wilson

R.A.S. Ref. No.	Subject.	Photographed by
61	Meteor Trail and Comet Brooks, 1893 Nov. 13	E. E. Barnard
62	Total Solar Eclipse, 1898 January 22 (5 sec.)	W. H. M. Christie
63	Total Solar Eclipse, 1898 January 22 (20 sec.)	W. H. M. Christie
64	Solar Corona, 1896 August 9, Novaya Zemlya	G. Baden-Powell
65	Solar Corona, 1898 January 22, Pulgaon, India	E. H. Hills
66	Nebula in *Andromeda*	Roy. Obs., Greenwich
67	Spectrum of Sun's Limb, 1898 January 22	E. H. Hills
68	Annular Nebula, *Lyra* (N.G.C. 6720)	Lick Observatory
69	Dumb-bell Nebula, *Vulpecula* (N.G.C. 6853)	Lick Observatory
70	Spiral Nebula, *Canes Venatici* (N.G.C. 5194–5)	Lick Observatory
71	Spiral Nebula, *Ursa Major* (N.G.C. 5457)	Lick Observatory
72	Trifid Nebula, *Sagittarius* (N.G.C. 6514)	Lick Observatory
73	Great Nebula in *Orion*	Lick Observatory
74	Cluster M 13 *Herculis* (N.G.C. 6205)	Lick Observatory
75	Solar Surface with Faculæ, 1893 August 7	G. E. Hale
76	Faculæ and Prominences, 1892 June 25	G. E. Hale
77	Total Solar Eclipse, 1898 Jan. 22 ($\frac{2}{3}$ sec.)	W. H. M. Christie
78	Nebula H V. 14 *Cygni* (N.G.C. 6992)	W. E. Wilson
79	Portion of Moon (Theophilus, &c.)	Yerkes Observatory
80	Total Solar Eclipse, 1900 May 28 (30 sec.)	E. E. Barnard
81	Comet 1901 I., 1901 May 4	Roy. Obs., Cape of G. H.
82	Comet 1901 I., 1901 May 6	Roy. Obs., Cape of G. H.
83	Comet 1901 I., 1901 May 9	Perth Obs., W. Australia
84	Solar Surface with Faculæ, 1895 August 18	H. Deslandres
85	Solar Prominences, 1894 April 11	H. Deslandres
86	Nebula about Nova *Persei*, 1901 Sept. 20	G. W. Ritchey
87	Nebula about Nova *Persei*, 1901 Nov. 13	G. W. Ritchey
88	Total Solar Eclipse, 1901 May 18 (10 sec.)	F. W. Dyson
89	Total Solar Eclipse, 1901 May 18 (40 sec.)	F. W. Dyson
90	Comet 1902 III. (Perrine), 1902 Sept. 29	Roy. Obs., Greenwich
91	Portion of Moon (Mare Serenitatis, &c.)	Yerkes Observatory
92	Portion of Moon (Regions of Mare Nubium)	Yerkes Observatory
93	Portion of Moon (Tycho, Theophilus, &c.)	Yerkes Observatory
94	Portion of Moon (Bullialdus to Copernicus)	Yerkes Observatory
95	Portion of Moon (Copernicus, enlarged)	Yerkes Observatory
96	Great Nebula in *Orion*	Yerkes Observatory
97	Great Nebula in *Orion* (Central portion)	Yerkes Observatory
98	Nebula in *Andromeda*	Yerkes Observatory
99	Nebula in *Cygnus* (N.G.C. 6960)	Yerkes Observatory
100	Nebula H V. *Cygni* (N.G.C. 6992)	Yerkes Observatory

R.A.S. Ref. No.	Subject.	Photographed by
101	Cluster M 13 *Herculis* (N.G.C. 6205)	Yerkes Observatory
102	Cluster M 15 *Pegasi* (N.G.C. 7078)	Yerkes Observatory
103	Solar Surface with Faculæ, 1903 April 27	Yerkes Observatory
104	The Moon, 1900 April 5	P. Puiseux
105	The Moon, 1902 November 13	P. Puiseux
106	The Moon, 1903 February 6	P. Puiseux
107	The Moon, 1903 September 12	P. Puiseux
108	Nebulosity about 15 *Monocerotis*	E. E. Barnard
109	Milky Way about β *Cygni*	E. E. Barnard
110	Nebulosity near α *Cygni*	E. E. Barnard
111	Milky Way near χ *Cygni*	E. E. Barnard
112	Star Cloud in *Sagittarius*	E. E. Barnard
113	Milky Way in *Cepheus*	E. E. Barnard
114	Milky Way about M 8	E. E. Barnard
115	Milky Way about θ *Ophiuchi*	E. E. Barnard
116	Milky Way near N.G.C. 6475	E. E. Barnard
117	Great Nebula near ρ *Ophiuchi*	E. E. Barnard
118	Milky Way about 58 *Ophiuchi*	E. E. Barnard
119	Milky Way near *Omega* nebula	E. E. Barnard
120	Star Cloud in *Sagittarius*	E. E. Barnard
121	Nebula about ν *Scorpii*	E. E. Barnard
122	Sun, 1905 January 30	Roy. Obs., Greenwich
123	Sun-spot, 1905 January 30	Roy. Obs., Greenwich
124	Sun, 1905 January 31	Roy. Obs., Greenwich
125	Sun-spot, 1905 January 31	Roy. Obs., Greenwich
126	Sun, 1905 February 2	Roy. Obs., Greenwich
127	Sun-spot, 1905 February 2	Roy. Obs., Greenwich
128	Sun, 1905 February 3	Roy. Obs., Greenwich
129	Sun-spot, 1905 February 3	Roy. Obs., Greenwich
130	Sun, 1905 February 5	Roy. Obs., Greenwich
131	Sun-spot, 1905 February 5	Roy. Obs., Greenwich
132	Sun, 1905 February 8	Roy. Obs., Greenwich
133	Sun-spot, 1905 February 8	Roy. Obs., Greenwich
134	Nebula near ψ *Eridani*, 1905 January 8	Max Wolf
135	Nebula M 33 *Trianguli* (N.G.C. 598)	Isaac Roberts
136	Nebula in *Perseus* (N.G.C. 1499)	Isaac Roberts
137	Nebula in *Monoceros* (N.G.C. 2237–9)	Isaac Roberts
138	Nebula H V. 24 *Comæ* (N.G.C. 4565)	Isaac Roberts
139	Nebulæ H V. 42, &c., *Comæ* (N.G.C. 4631)	Isaac Roberts
140	Nebula H V. 37 *Cygni* (N.G.C. 7000?)	Isaac Roberts

R.A.S. Ref. No.	Subject.	Photographed by
141	Nebula Index Cat. 405 *Persei*	Isaac Roberts
142	Clusters in *Perseus* (N.G.C. 869, 884)	Isaac Roberts
143	Cluster H VI. 30 *Cassiopeiæ* (N.G.C. 7789)	Isaac Roberts
144	Total Solar Eclipse, 1905 August 30 (5 sec.)	W. H. M. Christie
145	Total Solar Eclipse, 1905 August 30 (20 sec.)	W. H. M. Christie
146	Total Solar Eclipse, 1905 August 30 (7 sec.)	W. H. M. Christie
147	Total Solar Eclipse, 1905 August 30 (20 sec.)	W. H. M. Christie
148	Total Solar Eclipse, 1905 August 30 (Portion)	W. H. M. Christie
149	Region of Nebula ρ *Ophiuchi*	E. E. Barnard
150	Nebula ρ *Ophiuchi* (enlarged)	E. E. Barnard
151	Region of θ *Ophiuchi*	E. E. Barnard
152	Great Rift near θ *Ophiuchi*	E. E. Barnard
153	Great Star Cloud in *Sagittarius*	E. E. Barnard
154	Small Star Cloud in *Sagittarius*	E. E. Barnard
155	Region of Cluster M 11	E. E. Barnard
156	Sun-spots, 1906 July 6	Roy. Obs., Greenwich
157	Sun-spot, 1906 July 31	Roy. Obs., Greenwich
158	Sun-spot, 1906 August 30	Roy. Obs., Greenwich
159	Eclipse, 1905 August 30 (large prominence)	De la Baume Pluvinel
160	Comet *c* 1908, Sept. 7d. 14h. 56m.	Roy. Obs., Greenwich
161	Comet *c* 1908, Sept. 14d. 8h. 22m.	Roy. Obs., Greenwich
162	Comet *c* 1908, Sept. 29d. 13h. 12m.	Roy. Obs., Greenwich
163	Comet *c* 1908, Sept. 29d. 14h. 13m.	Roy. Obs., Greenwich
164	Comet *c* 1908, Sept. 29d. 15h. 19m.	Roy. Obs., Greenwich
165	Comet *c* 1908, Sept. 29d. 16h. 15m.	Roy. Obs., Greenwich
166	Comet *c* 1908, Oct. 3d. 9h. 4m.	Roy. Obs., Greenwich
167	Comet *c* 1908, Oct. 3d. 13h. 13m.	Roy. Obs., Greenwich
168	Comet *c* 1908, Oct. 27d. 10h. 2m.	Roy. Obs., Greenwich
169	Comet *c* 1908, Oct. 29d. 7h. 3m.	Roy. Obs., Greenwich
170	Comet *c* 1908, Oct. 30d. 7h. 47m.	Roy. Obs., Greenwich
171	Comet *c* 1908, Nov. 3d. 6h. 43m.	Roy. Obs., Greenwich
172	Comet *c* 1908, Oct. 1d. 8h. 55m.	Roy. Obs., Greenwich
173	Comet *c* 1908, Oct. 30d. 6h. 56m.	Roy. Obs., Greenwich
174	Comet *c* 1908, Sept. 30d. 20h. 57m.	E. E. Barnard
175	Comet *c* 1908, Oct. 1d. 14h. 45m.	E. E. Barnard
176	Comet *c* 1908, Oct. 1d. 19h. 15m.	E. E. Barnard
177	Comet *c* 1908, Oct. 15d. 12h. 57m.	E. E. Barnard
178	Sun-spot Vortices, 1908 Oct. 7	G. E. Hale
179	Total Solar Eclipse, 1908 Jan. 3 (16 sec.)	W. W. Campbell
180	Comet *c* 1908, Oct. 16d. 15h. 32m.	E. E. Barnard

R.A.S. Ref. No.	Subject.	Photographed by
181	Comet *c* 1908, Nov. 16d. 13h. 10m.	E. E. Barnard
182	Comet *c* 1908, Nov. 19d. 6h. 4m.	Roy. Obs., Greenwich
183	Comet *c* 1908, Nov. 22d. 5h. 55m.	Roy. Obs., Greenwich
184	Comet *c* 1908, Nov. 25d. 5h. 55m.	Roy. Obs., Greenwich

Nos. 44–55, Nos. 64, 65, and No. 147 form a series of corona photographs, oriented and reduced to the same scale.

The above photographs are now on sale to Fellows as prints, either platinotype or aristotype, mounted on sunk cut-out mounts, measuring 12 inches by 10 inches; also unmounted, and as lantern slides. Nos. 44–55 and Nos. 64 and 65 are also supplied as transparencies, $6\frac{1}{4}$ inches square.

Price of prints, mounted 1*s.* 6*d.* each, unmounted 1*s.* each; lantern slides, 1*s.* each; packing and postage extra.

Transparencies, $6\frac{1}{4}$ inches square (Nos. 44–55 and Nos. 64 and 65), 3*s.* 6*d.* each.

Orders to be addressed to W. H. Wesley, Burlington House, London, W. In ordering prints or slides the R.A.S. Reference No. only need be quoted, but in the case of prints it should be stated whether platinotypes or aristotypes are required, and whether mounted or unmounted.

The Gold Medal.

The Council have awarded the Gold Medal of the Society to Dr. Oskar Backlund for his researches on Encke's Comet. The President, in his Address to the Society, sets forth the grounds upon which the award has been founded.

The Jackson-Gwilt Medal and Gift.

The Council have awarded the Jackson-Gwilt Medal and Gift to Mr. Philibert J. Melotte, for his discovery of the Eighth Satellite of Jupiter.

Publications of the Society.

During the past year vol. lxviii. of the *Monthly Notices* has been issued.

The following volumes of the *Memoirs* have also been published:—

Vol. lvii. part iii. A. R. Hinks. Tables for computing standard co-ordinates on photographic plates.

,, part iv. F. J. M. Stratton. Proper motions of Faint Stars in the Pleiades; and W. H. Maw, Double-Star observations, 1902–1907.

Vol. lvii. Appendix ii. L. Becker. Distribution of blue-violet light in the Solar Corona on August 30th, 1905 (reprinted from the *Philosophical Transactions* of the Royal Society).

Vol. lviii. N. R. Pogson. Observations of thirty-one Variable Stars. Edited by C. L. Brook, with Introduction by H. H. Turner. (See Council Note on Variable Stars, p. 310.)

Vol. lix. part i. E. W. Brown. Theory of the motion of the Moon, part v.

„ part ii. J. L. E. Dreyer. Second Index Catalogue of Nebulæ and Clusters of Stars.

Obituary.

The Council regret that they have to record the loss by death of the following Fellows and Associates during the past year :—

Fellows :—William Morris Beaufort.
Lord Blythswood.
Cecil Goodrich J. Dolmage.
Robert Lewis John Ellery.
James Kennedy Esdaile.*
Edward Gay.
Frederick Howlett.
Henry Alfred Lenehan.
Percy Braybrooke Molesworth.
Earl of Rosse.
James Lidderdale Scott.
William Henry E. Thornthwaite.
Henry Thomas Vivian.
Thomas Weir.
William Edward Wilson.
Carl Venceslas Zenger.

Associates :—John M. Thome.
Charles A. Young.

The deaths of the following Fellows were not reported till 1908 :—

Pat Doyle (died 1907).
James Rankin (died 1906).
Edward Henry Riches (died 1907).

William Morris Beaufort was the youngest son of Admiral Sir Francis Beaufort, K.C.B., F.R.S., who was Hydrographer of the Admiralty from 1827 to 1855, and one of the original Fellows of the Society. William Morris Beaufort was born at 57 Manchester Street, Manchester Square, London, on the 20th July 1823, and was educated at St. Paul's School, from whence, in 1840, he proceeded to Haileybury, which was then the East India College. Two years later he sailed for Calcutta, where he joined the Bengal Civil Service, in the judicial ranks of which he served till he retired in 1871. In 1857, while on leave in England, he became a barrister-at-law, but he never practised. Shortly after his return to England he took the rooms at 18 Piccadilly where he lived up to the time of his death on the 13th of December last, in his eighty-sixth

* Obituary in Annual Report for 1907.

year. He was a member of the Athenæum Club and a Fellow of several learned societies besides the Royal Astronomical, including the Royal Geographical, Royal Meteorological, and Royal Statistical and Zoological Societies, and the Anthropological Institute. He served on the Council of the Meteorological Society from 1883 to 1890, and was Vice-President in 1885. He was also a Fellow and for some time on the Council of the Huguenot Society, and for twenty-six years, to the time of his death, a Director of the French Hospital at Victoria Park (on the list of which his great-grandfather, the Rev. Daniel de Beaufort, appears as having joined in 1736), an institution which was incorporated by royal charter in 1718. For some years he was Secretary of the French School attached to the French Protestant Episcopal Church of the Savoy in Shaftesbury Avenue, and till quite recently the treasurer of that church, the poor fund of which gives monthly subscriptions to fifty pensioners, the descendants of Huguenot refugees who fled from France at the Revocation of the Edict of Nantes in 1685, when his own ancestors left that country for the same reason. His gifts to the poor and to innumerable charitable institutions were known to few, as his name never appeared in the published lists.

He was elected a Fellow of the Society on 1877 May 11.

Archibald Campbell Campbell, first Lord Blythswood, was the son of Archibald Campbell of Blythswood, seventeenth Laird of Mains, and was born 1835 February 22. Lord Blythswood's father exchanged the name of Douglas for Campbell on succeeding to the estate of his cousin, Major Campbell, twelfth Laird of Blythswood, and at one time M.P. for Glasgow. The estate comprised a great portion of the land on which the western part of the city of Glasgow is built. At the age of twenty Lord Blythswood joined the Scots Guards, and immediately went with the regiment to the Crimea. After three months' service he was severely wounded in the trenches before Sebastopol; he received the Crimean medal with clasp and the Turkish medal. He retired from the army with the rank of lieutenant-colonel on the death of his father in 1868. In 1864 he married the elder sister of the present Lord Carrington. He was created Baronet in 1880, was Lord Lieutenant of the county of Renfrew, and Aide-de-camp to the late Queen Victoria; he was a keen politician, and sat in Parliament as a Conservative for West Renfrewshire from 1883 until 1892, when he was raised to the peerage. On many occasions he entertained members of the Royal Family when they visited Glasgow, and in November 1907 the freedom of the city of Glasgow was conferred upon him, with special recognition of the splendid hospitality dispensed at Blythswood House, on the north bank of the Clyde.

Although he had many interests, much of his time was devoted to physical science: he established a laboratory and workshop at Blythswood House, and fitted them with the best instruments that could be procured. In the Glasgow Exhibition of 1888 he exhibited the wheel-work for an astronomical driving-clock, cut

with his own hands; many excellent gratings were made with a ruling engine of his own device, the result of twenty-five years, modification and improvement. In this engine the diamond point is brought very gradually into contact with the surface to be ruled, so that the risk of disaster from its breaking is entirely avoided. When Röntgen announced the discovery of the X-rays, Lord Blythswood had already obtained photographic effects through opaque objects, and had come very near to making the discovery himself. His principal researches were in spectrum photography, the Zeeman effect, and in radio-activity. During the last few years of his life he was much interested in the problem of flight, and in conjunction with Mr. Scoble he invented an engine worked by compressed air, and which developed one-half of a horse-power, although weighing only two pounds.

He had for some time been suffering from heart weakness, and died on July 8 at his seat of Blythswood.

Lord Blythswood was elected a Fellow of the Royal Society in 1907, and a Fellow of the Royal Astronomical Society on 1875 April 9.

Cecil Goodrich Julius Dolmage was descended from a Protestant refugee family which settled in Ireland at the beginning of the eighteenth century. He was born in Naples in 1870. He received his early education at Ipswich School and from private tutors, and at the age of seventeen he passed successfully his examinations for the army. But an accident following almost immediately upon this success, weakened his constitution and altered the course of his career, and, as it has since proved, cut short a life that was full of promise.

He was, however, within a year or so of this unfortunate mishap, which so changed his life, able to enter Trinity College, Dublin, and after a distinguished course there he graduated, taking high honours in history and political science, in 1893, and, later, the degrees of M.A. and LL.D.

He was called to the Irish Bar in 1897, and to the Bar of the Inner Temple in 1903.

Mr. Dolmage wrote many articles and essays on historical and astronomical subjects. His book, *Astronomy of To-day*, appeared but a few weeks before his death last autumn, and showed him to be gifted with the power of a sympathetic insight and a facile pen.

He was only thirty-eight when he died from a decline which followed upon the unfortunate accident of his earlier years.

He was elected a Fellow of the Society on 1898 November 11.

Robert Lewis John Ellery was born at Cranleigh in Surrey on the 14th of July 1827. In early life he studied medicine, but devoted much of his leisure to astronomy and meteorology. He first went to Australia in 1851, and superintended in 1853 the erection of a small observatory at Williamstown for the Government of Victoria, which was constituted a separate colony in that

year, having previously formed a part of New South Wales. The new establishment was removed to a more suitable site at Melbourne in 1863, and was provided in 1870 with a Grubb reflector, 4 feet in aperture and of 20 feet focal length. Mr. Ellery continued to direct its operations until 1895. Eight volumes of astronomical and twenty-eight of meteorological appeared under his directorate, besides two valuable star-catalogues, which were published in 1874 and 1889, and contain the places of 1227 and 1211 stars respectively. Besides his astronomical and meteorological work, Mr. Ellery was much occupied from 1857 to 1870 in the geodetic survey of the colony. Many separate papers by him (chiefly on observations of comets and casual phenomena) appeared from time to time in the *Monthly Notices* of the Royal Astronomical Society, and in the *Transactions* of the Royal Society of Victoria; he held for twenty-three years the post of President of the latter. In addition to all this, he organised and for a time commanded the Victorian Torpedo Corps, now called that of the Submarine Mining Engineers; in retiring from this in 1889 the rank of lieutenant-colonel was conferred upon him. On completing his sixty-eighth year, Mr. Ellery resigned the Directorship of the Observatory, but continued to reside in Melbourne, and held the post of Chairman of the Board of Visitors until his death, which occurred on the 14th of January 1908. Being on a visit to England in 1875, he was present, with the other Directors of southern observatories (Stone of the Cape, and Russell of Sydney) at the dinner given by Airy on the occasion of the bi-centenary of the foundation of the Royal Observatory on the 10th of August. His successor in the Directorship at Melbourne was Mr. Baracchi.

Mr. Ellery was married twice; the first time in 1853, soon after he came to Australia; but his wife dying in 1856, he married two years afterwards a daughter of Mr. Shields of Launceston, Tasmania.

He was elected a Fellow of this Society 1859 July 8, and of the Royal Society in 1873. W. T. L.

Edward Gay, the younger son of James Gay, was born at Dulwich on 1837 December 5. In 1854 he was nominated to a clerkship in the Secretary's department of the General Post Office. He afterwards gained a clerkship at the Treasury, and while holding this appointment he matriculated at Magdalen Hall, Oxford, where he took his degree of B.A. in 1861, and of M.A. in 1863. In 1864 he was selected by Sir Charles Trevelyan to serve in the Financial department of the Indian Civil Service, where he passed through the various grades, until in 1879 he became Accountant-General, Bombay, and Commissioner of Paper Currency. Nine years later he became Controller and Auditor-General, and Head Commissioner of Paper Currency. Mr. Gay's official work allowed but scanty time for astronomical pursuits, but he was always much interested in following the various developments. In 1876 he married Ellen, third daughter of Mr. Thomas Nelson, Waterfield, formerly head of the Secret Political Department in the India Board. In 1891 Mr. Gay retired, and made his home at Oxford

till the autumn of 1907, when he removed to Aldeborough Hall, near Norwich. His death occurred on 1908 April 3. He leaves a widow, one son, and one daughter.

He was elected a Fellow of the Society 1872 December 13.

Frederick Howlett, a most persevering observer in one department of astronomy, was born in 1821, and died on the 30th of January 1908. After completing his Oxford course, he took holy orders at the usual age, and served first a curacy in the Lake District, where he became acquainted with the poet Wordsworth. The latter seldom refers to astronomy in his poems, but on one occasion he describes the solar eclipse (annular in some places, but a large partial one there) of the 7th. of September 1820, as witnessed from Lake Lugano in North Italy. From Westmoreland Mr. Howlett removed to Hurst Green in Sussex. Whilst there he was a near neighbour of Sir John Herschel, with whom he became very intimate; this intimacy had the natural effect of increasing his early taste for astronomy. Elected a Fellow of the Society in 1861, he took up very energetically the subject of solar spots, of which he obtained a large number of drawings by the method of projection on a screen. After a comparatively short tenure at Beckenham, Kent, Mr. Howlett was preferred to the rectory of East Tisted in Hampshire, where he continued for nearly thirty years, occupied in parochial work and in his astronomical studies, being also much interested in microscopy as applied to vegetable and to the lower forms of animal life. When he felt that he could no longer continue his observations, he presented a complete set of drawings of the solar phenomena, extending over more than thirty years, to the Society. A very interesting result of his observations is the possible untenability of what is called the Wilsonian theory of solar spots. Alexander Wilson, who originated it in 1769, was the first Professor of Astronomy at Glasgow, and a friend of Sir William Herschel, who visited him there. It was contested from the first, but gradually obtained acceptance, and found its way into a large number of popular books, with a rather fanciful drawing showing the effects of perspective on the supposed cavernous spots. Mr. Howlett found this appearance to be in many cases inconsistent with careful observation, thus concluding that when the spots are at a lower level than the surface of the photosphere, the depression is too shallow to exhibit the phenomenon in question with certainty. To quote Miss Clerke (*Hist. Astr.*, p. 155), "We can only infer that the forms of sun-spots are really more various than had been supposed; that they are peculiarly subject to disturbance; and that the level of the nuclei may rise and fall during the phases of commotion, like lavas within volcanic craters."

Mr. Howlett's amiable and kindly disposition greatly endeared him to his parishioners, and he was much esteemed by a large circle of friends. His wife was a daughter of Sir William Rawson (formerly Adams), and sister to Sir Rawson William Rawson.

She died at East Tisted, leaving no family; and soon afterwards Mr. Howlett resigned his living and went to reside at Clifton. An attack of paralysis rendered him a permanent invalid during the last three or four years of his life, but he continued almost to the last to take an intelligent interest in the progress of science.

He was elected a Fellow of the Society 1861 March 8.

W. T. L.

Henry Alfred Lenehan was born at Sydney, N.S.W., on August 29, 1843. He was the son of the late Mr. Andrew Lenehan, a gentleman well known in the mercantile community of the young state. Mr. Lenehan was educated at Lyndhurst College, a local institution presided over by the Jesuit priests. On leaving school he remained sometime in his father's business, and afterwards proceeded to Queensland to take up an appointment in the Australian Joint Stock Bank. About this time, the early sixties, the State of Queensland was being surveyed for construction of railways, and Mr. Lenehan, having a penchant for such work, joined the survey. He returned to New South Wales in 1870, and received an appointment on the Observatory Staff under the late H. C. Russell, and so became one of the observers of the transit of Venus, 1874. He afterwards had control of the Transit Circle. In 1875, 1877, and 1901 he was Acting Government Astronomer during Mr. Russell's absence, and again, on the death of the latter, in 1903. On January 1, 1907, he succeeded to the appointment of Government Astronomer, a position he held at the time of his death, which occurred 1908 May 2. Mr. Lenehan was therefore connected with the observatory nearly thirty-eight years. At the time of his death he had nearly completed arrangements for the purchase of a 15-inch refractor for the observatory. Mr. Lenehan was a member of the Royal Society of N.S. Wales, served on its Council a considerable time, and was elected President 1905–6. In 1892 Mr. Lenehan paid a visit to Europe to study the working of various observatories. He leaves a widow and six children.

He was elected a Fellow of the Society 1894 January 12.

Percy Braybrooke Molesworth, Major R.E., youngest son of Sir Guilford Molesworth, K.C.I.E., was born at Colombo, Ceylon, on the 2nd of April 1867. He was educated at Winchester College, and obtained his commission in the corps of Royal Engineers in February 1886.

After passing through the Royal Military Academy at Woolwich and Chatham (where he obtained the Fowke Medal), he was stationed at Fort Camden, Queenstown Harbour, until 1891, when he was ordered to Hong Kong for three years, and after his return he applied for service in Ceylon, where he was engaged in perfecting the defences of Trincomali. He joined the Solar Eclipse Expedition to India, organised by the British Astronomical Association in 1898, and towards the end of that year he was temporarily seconded in order to act as Secretary to Sir Guilford Molesworth, to visit and report on

the Uganda Railway on behalf of the Foreign Office, returning to Trincomali about the middle of 1899. He obtained his majority in 1904, and retired from the service in 1906, having purchased an estate near Trincomali, intending to devote his leisure entirely to astronomical observation. His health, however, was injured by overwork, and on his return from a short visit to England he succumbed to a severe attack of dysentery, and passed away on Christmas day 1908.

From his early school days he took an intense interest in astronomy, the study of which he pursued, not merely as a pastime, but in a scientific spirit. He established an observatory at Trincomali, with instruments for observation and photography, including a $12\frac{1}{2}$-inch reflecting telescope, specially built for him by Calver; but his failing health precluded the removal of the observatory to his estate after his retirement from the service.

As a keen-sighted and competent observer, and a skilful draughtsman, Major Molesworth was in the very forefront of amateur astronomers. His observational work was chiefly on the planets Mars and Jupiter, and certain special lunar formations, though he was also interested in other departments of astronomical observation. He communicated to the Royal Astronomical Society two full reports of his observations of Jupiter in 1903–4 and 1904–5, which were published in vols. lxv. and lxvi. of the *Monthly Notices*. His observations of Mars in 1903, accompanied by drawings, were partly published in the *Monthly Notices*, his complete manuscript report being placed in the Society's library. The value and importance of his work is also shown in sundry memoirs of the Mars, Jupiter, and Lunar Sections of the British Astronomical Association, and students of Jupiter will remember that he was the first to detect, in February 1901, the beginning of what has since become one of the most important and interesting features of the planet, the great disturbance on the S. tropical zone. He also obtained some valuable photographs of the great comet visible in more southern latitudes in 1901. But the amount of care and trouble expended on his work, his enthusiasm, and his exceptional ability as an observer can be fully appreciated only by those who have had the opportunity of seeing his original entries and drawings, for his published papers represent but a small part of all he really accomplished. During the last few years, though his interest remained as keen as ever, he was compelled to give up astronomical work owing to the pressure of other duties, but it was his intention to take it up again at the earliest opportunity.

He was elected a Fellow of the Royal Astronomical Society 1898 June 10.

James Rankin was born at Motherwell, N.B., in 1832, his parents being natives of the island of Jura, N.B., where the family had resided more than a century. Mr. Rankin was for over twenty years Assistant Examiner of Seamanship and Navigation under the Local Marine Board, London. While here, he was also engaged on investigations connected with tidal phenomena. He also devoted

much time to Semitic languages and literature, mainly Hebrew and Chaldean, and was for some time a member of the Royal Asiatic Society. His death occurred on 1906 June 4, in London. Mr. Rankin's wife died in 1884; he leaves three daughters and one son, D. J. Rankin, F.R.G.S., M.R.A.S.

He was elected a Fellow of the Society 1879 January 10.

Edward Henry Riches was born at Leicester 1844 March 21. He was the son of Alfred Smith Riches, who was for many years Solicitor to the University of Cambridge. Mr. Riches was headmaster of a large preparatory school at Dulwich for many years. In 1878 he retired and lived at Scarborough, then at Bournemouth, and afterwards at Weymouth, where he died. He was the author of a number of schoolbooks, and his algebra had a large sale. He contributed articles on Astronomy to the *Leisure Hour*; he was a good speaker, and gave lectures gratuitously for charitable purposes. He married the daughter of Professor Labatt, of Berlin. His wife died in 1901; he leaves one daughter. He died of cancer, at Weymouth, 1907 August 21.

He was elected a Fellow of the Society 1870 April 8.

Lawrence Parsons, fourth Earl of Rosse, was born at Birr Castle, Parsonstown, King's County, on the 17th November 1840. He was the eldest of the four sons of the third Earl, the maker of the celebrated six-foot reflecting telescope. He was only five years old when this mighty instrument was completed, and at once revealed the existence of spiral nebulæ. Lord Oxmantown (as he was during his father's lifetime) was educated at home, and his childhood and youth were therefore spent close to the observatory and workshops of his father, whose position as one of the leading men of science of his day brought him into contact with many distinguished men, whose acquaintance his son thus had the great privilege of making at an early age. Being brought up in close association with his father, it was natural that the son should become deeply imbued with the taste for mechanical engineering and laboratory work, which had enabled the third Earl to produce the great telescope without any help from the experience of previous makers of reflectors to guide him; and throughout his life Lord Rosse delighted in working in his own well-furnished workshop, and making various additions to the equipment of the observatory with his own hands. In due course he entered Trinity College, Dublin, and took his degree in 1864. Soon afterwards he began to take part in the observations with the 6-foot and 3-foot telescopes, and chose as the subject of his first scientific memoir the great nebula of Orion. This object had been very frequently examined at Birr Castle, and all the available material of drawings and descriptive notes (chiefly by Mr. Hunter, observer, 1860–64) was now worked up, verified, and used for the production of the well-known large and beautiful drawing published in the *Philosophical Transactions* for 1868. Though photography has now put an end

to the use of pencil and stump for the delineation of nebulæ, the great drawing of the Orion nebula will always be of value as a faithful representation of its appearance in the largest telescope of the nineteenth century.

In October 1867 Lord Rosse lost his father, and succeeded to the title and estates. In the following year he took up the work by which he will no doubt be best remembered in the annals of astronomy—the investigation of the Moon's radiant heat. Some slight attempts at measuring this had been made by others, but Lord Rosse was the first to study the subject perseveringly, and his efforts were crowned with considerable success. In the focus of the speculum of three-feet aperture he placed two thermopiles with poles in reversed position, using at first piles made by Messrs. Elliott, but soon replacing them with others made by himself. His first results, showing the great possibilities of the method, were published in the *Proc. R.S.*, vols. xvii. and xix. In 1871–72, when he had secured the assistance of Dr. Copeland, the work was carried on more systematically, and resulted in the well-known memoir "On the radiation of heat from the Moon, the law of its absorption by our atmosphere, and of its variation in amount with her phases" (*Phil. Trans.*, 1873). In this paper it was shown that the heat varied very nearly as the light, becoming almost imperceptible toward new moon, and that barely twenty per cent. was transmitted by glass.

While thus breaking new ground in celestial physics, Lord Rosse did not as yet abandon the work on nebulæ, on which the 6-foot reflector had been more or less regularly employed since the year 1848. In 1869 he applied a clock movement to this instrument which made it possible to take fairly accurate micrometer measures, even of difficult objects such as the satellites of Uranus, and enabled the observer to determine the relative places of the many new nebulæ found with the telescope, of which formerly only very rough positions had been given by the observers. Encouraged by this success, he decided to replace the old altazimuth mounting of the 3-foot telescope by an equatorial mounting, which was carried out in the years 1874–76, the mounting and lattice tube being made, not as usual in his own workshop, but (mainly after his designs) by a Dublin contractor.* In the meantime the long series of observations of nebulæ was systematically put together, examined and supplemented by new observations and measures, chiefly in order to re-examine the newly found objects, until the work was finally brought to a close in 1878. Other occupations prevented Lord Rosse from undertaking himself the preparation for the press of this work, but it contains many observations made by him. It was published in 1879–80 in the *Transactions* of the Royal Dublin Society. Though the rapid development of refracting telescopes of great power, and particularly the rise of astronomical photography of late years, have over-

* See his paper "On some recent improvements made in the mountings of the telescopes at Birr Castle" (*Phil. Trans.*, 1880).

shadowed the work done with the once famous "Lord Rosse's telescope," it will never be forgotten that we owe to it the discovery of the spiral form of nebulæ, and that this form, which now is known to be characteristic of a large proportion of these objects, could for many years be perceived only by means of that instrument. It is perhaps to be regretted that it has not since 1878 been used for observing nebulæ, as there are still several fields of work open in this direction for a very powerful instrument, notwithstanding the competition of the photographic plate. But Lord Rosse felt more drawn to other branches of astrophysics, and in particular he never lost sight of the subject of lunar heat, on which from time to time work continued to be done at his observatory. This was notably the case during the total lunar eclipses of 1884 and 1888, when the interesting observation was made, that though a rapid fall, almost to zero, took place during the first half of the eclipse, the heat after totality continued to be very much below the standard for full moon, even after the last contact with the penumbra. As it seemed unlikely that much further progress could be made with his apparatus, and under the unfavourable atmospheric conditions of his home, he designed a cheap and simple apparatus in order to encourage others to pursue his favourite study in more favourable localities. In this instrument, a 24-inch searchlight mirror of short focus, silvered on the front face, supplies the place of his 3-foot telescope. It was exhibited at the Franco-British Exhibition in London in 1908, where a leaflet describing it was distributed. He had hoped himself to exhibit another copy of this instrument at the Dublin meeting of the British Association, but his health, which had been declining for about two years, finally broke down shortly before that meeting, and he died on the 30th August 1908.

Although Lord Rosse did not publish any scientific papers during the last years of his life, his time was always fully occupied, both with scientific and other work. Since 1869 he was a representative Peer for Ireland, and from 1885 Chancellor of the University of Dublin. He was President of the Royal Dublin Society from 1887 to 1892, and of the Royal Irish Academy 1895–1900. Though of a very retiring disposition, and unwilling to appear in public, his feeling of duty made him devote much time to public affairs, not only as a representative of science (as, for instance, on the committee to investigate the danger threatening the Royal Observatory from the electric generating station at Greenwich), but also on local boards, and as a member of the Irish Church representative body. His genial presence will be missed at scientific meetings, where he was a very regular attendant.

Lord Rosse married in 1870 the Hon. Frances Cassandra Hawke, only child of the fourth Baron Hawke; he leaves two sons and a daughter. By his will he left £2000 in trust for the upkeep of his telescopes, while the instruments themselves were left to his sons and brothers, successively, and failing them, to the Royal Society.

He was elected a Fellow of the Society 1867 December 13, having been elected a Fellow of the Royal Society in the same year.

J. L. E. D.

James Lidderdale Scott, son of the late Andrew Scott, was born in Edinburgh in 1848. At the age of twenty-one he joined a mercantile firm in Shanghai, and continued to live there until a few weeks before his death. At the age of forty, though a very busy man, he commenced the study of astronomy. Having carefully surveyed the various fields of work, he decided to devote such time as could be spared to the measurement of double stars. To this end he secured a 5-inch Grubb refractor, and, in spite of frequent interruptions through illness, made many valuable measures, which he sent to the British Astronomical Association. His later measures have been published in the *Monthly Notices*. These observations of southern doubles came at a most opportune time, and Mr. Scott, finding that he could do good work with his 5-inch, was anxious that it should be in the direction most needed. In 1906, being on a visit to England, he obtained a good working catalogue, and the results of his measures on his return to Shanghai appeared in the *Monthly Notices*, 1908 April. Mr. Scott did not live to see their publication, for, leaving China early in 1908, he succumbed to an illness, dying on board ship on April 16, at the age of sixty. He married, in 1881, Margaret, eldest daughter of F. Maclean, of Shanghai, who survives him. There was no issue.

He was elected a Fellow of the Society 1891 June 9.

William H. E. Thornthwaite was born 1850 June 26, at Alwyn Place, Canonbury, N. His practical ability in the art of optical science was manifested at an early age, and while serving in his father's workshop he produced some excellent work. He was not merely a master of his trade, but a practical and even eloquent exponent of it, being possessed of the happy gift of imparting knowledge and of interesting students in details. To these advantages he added a genial manner and a persuasive tongue. He was for twenty years a Liveryman of the Worshipful Company of Spectacle Makers, and finally Master. In this position he brought his influence to bear in furthering and completing the scheme initiated by the guild for the technical education of rising opticians. In 1897–8 he was Chairman of the Board of Examiners, and so highly were his services appreciated in this capacity, and in his zeal for the scheme in general, that his fellow Liverymen of the Spectacle Makers' Company, and a large number of members of the optical industry, joined in presenting him with an equatorial telescope made by Sir H. Grubb. This instrument he lent to the Northampton Polytechnic, where it is much appreciated. Mr. Thornthwaite was also a keen entomologist, and possessed a representative collection of British Lepidoptera. At the time of his death, which occurred suddenly on 1908 June 1, he was Chairman

of the Gresham Life Assurance Company, a position formerly held by his father. He was also a skilled musician. He was widely known and respected, and the news of his sudden death was received with feelings of deep regret. He leaves a widow and one son.

He was elected a Fellow of the Society 1875 February 12.

Thomas Weir was born at Greenock in 1843, and educated at the Highlanders' Academy in that town. He was trained as an engineer with the Greenock Foundry Company. He afterwards came to England and was for some time manager in an engineering firm, subsequently joining the staff of the Vulcan Boiler and General Insurance Company, in whose service he remained till his death.

From his youth Mr. Weir was an ardent student of science, particularly of astronomy, which became his hobby and monopolised most of his spare time. He was one of the original members of the British Astronomical Association, and acted as Honorary Secretary of the North-Western Branch from its inception till it was merged in the Manchester Astronomical Society, of which he was elected the first honorary member.

Mr. Weir joined the solar eclipse expedition to Vadsö in Norway in 1896, and also that to Plasencia in Spain in 1900. On both occasions he made some excellent drawings and diagrams, which were used to illustrate several interesting and instructive lectures he delivered in and around Manchester.

In 1902 Mr. Weir was overtaken by paralysis, and, never recovering his strength, was compelled to relinquish the active part he had taken in furthering the interests of the science to which he was so devoted. After a long and painful illness, he gradually sank and died on 15th February 1908, in the sixty-fifth year of his age.

He was elected a Fellow of the Society 1899 February 10.

William Edward Wilson was born in 1851, and was the only son of Mr. John Wilson, of Daramona, Westmeath. In consequence of delicate health he was educated at home, and soon evinced a taste for astronomy. He took part in the Expedition to Oran to observe the total solar eclipse of 1870 December 22, and the following year he set up for himself a private observatory in his father's grounds at Daramona. This he equipped with a 12-inch reflector by Grubb. In 1881 he erected a larger observatory, which contained a fine and well mounted reflector of 2-feet aperture. A physical laboratory and a mechanical workshop were added in 1889, and in 1891 the telescope was remounted and furnished with electric control for astronomical photography. With this he obtained a great number of astronomical photographs, amongst which may be specially mentioned the great nebula in Orion, the annular nebula in Lyra, the spiral nebula in Canes Venatici, and the globular cluster M 13 in Hercules. All these, with several

others, are reproduced in the Society's series of astronomical photographs.

One of his most important memoirs was entitled "Experimental Investigations on the Effective Temperature of the Sun"; in this he found that the effective temperature could not differ much from 8000° C. In a second paper on the same subject, taking the lowest estimate of terrestrial atmospheric absorption, and correcting for solar atmospheric absorption, the value finally reached is 6590° C. Other important publications were on "The Absorption of Light in the Solar Atmosphere"; "The Temperature of the Carbons in the Electric Arc"; "The Effect of Pressure of the Surrounding Gas on the Temperature of the Crater of an Electric Arc Light"; "Radiation from a Perfect Radiator"; "The Thermal Radiation from Sunspots." In the last-mentioned paper he arrives at the conclusion that a sun-spot is not a cool, depressed region, but rather a more intensely heated one, raised above the photosphere. The papers published before 1900 were re-issued in a volume called "Astronomical and Physical Researches made at Mr. Wilson's Observatory, Daramona, Westmeath." This was illustrated with some of his celestial photographs. He observed the total solar eclipse of 1900 May 28 at Placencia (Spain), and his results were published in the *Transactions* of the Royal Irish Academy and the Royal Dublin Society.

Dr. Wilson married in 1886 Caroline Ada, daughter of Captain R. C. Granville, of Grand Pré, Biarritz, who survives him. He leaves also a son and two daughters.

He was elected a Fellow of the Royal Society in 1896, and received the honorary degree of D.Sc. from Dublin University in 1901. He became a fellow of the Royal Astronomical Society 1875 December 10.

Carl Venceslas Zenger was born 1830 December 17 at Komotau, Bohemia, and educated at the University of Prague. From 1851 to 1853 he was an Assistant at the Observatory; in 1853 he was appointed Professor in the Gymnasium at Neusohl, Hungary. In 1861 he returned to Prague as Professor of Physics in the Polytechnic Institute. In 1864 he was appointed an ordinary Professor at the Technical High School, of which in 1872 he became Rector. In 1899 he became Emeritus Professor of Astrophysics. He was a voluminous writer on Meteorology, Spectroscopy, and Astronomy. The majority of his papers appeared in the *Comptes Rendus*, and in the Journal of the Prague *Wissenschaftliche Gesellschaft*, but he contributed also a few to the *Monthly Notices* and to the *Philosophical Magazine*. He died January 22nd, 1908.

Professor Zenger was elected a Fellow of the Society 1875 June 11.

John Macon Thome was born at Palmyra, Pennsylvania, U.S.A., on August 22, 1843. He received a college education, and in 1870 took the degree of D.Sc. at the Lehigh University. In 1870 Dr. B. A. Gould was appointed by the Argentine Government to

establish a national astronomical observatory at Cordoba, where he arrived in September of that year. The selection of Cordoba as an especially desirable place was chiefly due to Lieutenant Gilliss, whose astronomical mission to Santiago de Chile, 1850–1852, enabled him to form a sound judgment as to the relative advantages of different points in South America for astronomical purposes. Before leaving the United States, Dr. Gould had engaged four assistants, of whom Dr. Thome was the senior, and they arrived at Cordoba at the end of September 1870. At this time Dr. Thome possessed no special astronomical training or experience. His subsequent career and the excellent work that has been accomplished at the Cordoba Observatory show the wisdom of Dr. Gould's selection. Speaking in after years of his assistants, Dr. Gould said he had been singularly favoured. "Their unselfish devotion to the great undertakings in which they took part, their loyalty, trustworthiness, and ability, have been beyond all praise."

In Dr. Gould's absence in 1874 and 1876 the observatory was left in charge of Dr. Thome, and on Gould's resignation in 1885 Thome was appointed Director.

Thome's directorship of the Cordoba Observatory began under most depressing and disadvantageous circumstances. He was practically alone, for Mr. Tucker, his one assistant, had only just joined him, and the condition of things was aggravated by the disastrous financial crisis which shortly ensued in Argentina, which rendered all his efforts to increase the staff, by engaging men abroad upon a paper basis, without result. In his own words, "the effort to maintain the activity and honourable record of the institution upon the smaller salaries consequent upon a vanishing budget, which cut off from me all hope of obtaining trustworthy help abroad, has been attended with painful experiences, and I have repeatedly been compelled to stop and train new men, and to repeat operations performed by inefficient and negligent or designing assistants."

But Thome's zeal and devotion were quite undeterred by such adverse conditions, and he determined to undertake the great task of continuing the *Durchmusterung* of Argelander and Schönfeld to embrace nearly the whole of the southern heavens. For this work he employed a portable equatorial with an object-glass by Alvan Clark of 12·5 cm. aperture and 168 cm. focal length, and the plan of operation was similar to that adopted at Bonn, except that transits were recorded chronographically instead of by the particular eye and ear method of Argelander.

The Cordoba *Durchmusterung* has been completed for the region from 22° to 65° south declination. The results are contained in four volumes (of which three have at present been distributed), and give the positions and brightness down to the 10·5 magnitude of 630,000 stars, resulting from over 1,800,000 observations. Eighteen charts, containing 550,000 stars, have also been prepared. The larger part of the observations for this great and valuable work were made by Thome. Indeed, for the four years 1894–1897

he made every observation himself, with the assistance of Mrs. Thome and Mr. Schuldt as recorders. It is impossible not to speak in the highest terms of the ability and untiring devotion of Thome in prosecuting and accomplishing this important and valuable contribution to astronomy. He will always occupy an honourable place in the roll of great workers in that science.

In the year 1900 the Paris Astrographic Congress resolved to ask the Cordoba Observatory to take over the photographic zone between the 23rd. and 31st. degrees of south declination, which had been previously assigned to the observatory at La Plata. This was accepted by Thome, and by the beginning of 1902 his observatory was equipped with an astrographic telescope by Gautier and all necessary apparatus; since then the work has been prosecuted with the Director's characteristic energy.

Though no paper by Thome appears in the publications of this Society, he contributed various papers to astronomical journals on comets, variable stars, minor planets, etc.

He died at Cordoba rather suddenly on September 27, 1908.

He was elected a Foreign Associate November 10, 1899.

E. B. K.

Charles Augustus Young was born on December 15, 1834, at Hanover, New Hampshire, U.S.A., a small town chiefly notable as the site of Dartmouth College—one of the older institutions of learning of New England—in which his grandfather and his father successively occupied the Chair of Natural Philosophy, and from which he himself received the degree of Bachelor of Arts in 1853, graduating with distinction.

After four years spent in teaching the classics and in theological studies, he accepted the post of Professor of Mathematics and Natural Philosophy at Western Reserve University in Ohio, which he held for nine years. In 1862 he was for four months captain in one of the many volunteer regiments of the Federal army, returning after service in the Mississippi swamps with impaired health, which was never quite restored.

In 1868 he returned to his own college—Dartmouth—as Professor of Natural Philosophy and Astronomy, and in 1877 he accepted a call to the Professorship of Astronomy at the College of New Jersey (now Princeton University), which he held for twenty-eight years. Retiring in 1905 on account of failing health and strength, he was appointed Professor-Emeritus, but returned to his old home in New Hampshire, where he died, after a short illness, on January 3, 1908.

At the time when Professor Young's scientific career began, the spectroscope was just taking its place as a new and powerful instrument of astrophysical research. In spite of heavy duties as a teacher, he did not content himself with expounding the new discoveries to his students, but engaged actively in solar research.

Observing the total eclipse of 1869 at Burlington, Iowa, he was able to demonstrate for the first time the solar character and

(at least partially) gaseous nature of the corona by his discovery of the green line (λ 5304) in its spectrum, whose wave-length he approximately determined, identifying it with the chromospheric line at λ 5317. The latter, just before totality, is conspicuously bright in the spectrum of the Sun's limb, but fades out in a few seconds after totality begins, when the much fainter coronal line becomes visible. With the low dispersion of even the most powerful instruments of that day the difference in position of the two lines is far from conspicuous, and it is not surprising that it remained unnoticed until the measurements of Lockyer in 1898, confirmed by Campbell in 1899, from independent observations made in the eclipse of 1898. At the eclipse of 1900, Professor Young planned to observe (visually) the fading out of the chromosphere line and the appearance of the coronal, but was defeated by the abnormal faintness of the latter, which (on one limb of the Sun at least) was quite invisible, though the continuous spectrum of the corona was conspicuous.

At the instant when this might have been seen in 1869, Professor Young was looking for a phenomenon of greater importance, predicted on theoretical grounds, which he was the first to observe at the Spanish eclipse of the following year—the "flash spectrum." His own description is: "The very instant the Sun is hidden, through the whole length of the spectrum the red, the green, the violet, the bright lines flash out by hundreds and thousands, almost startlingly; as suddenly as stars from a bursting rocket-head, and as evanescent, for the whole thing is over in two or three seconds."

From this observation he concluded that the bulk of the absorption which produces the Fraunhofer lines originates in a thin stratum, but a few hundred miles in thickness, directly above the photosphere, which he named the "reversing layer." This theory, though for many years a subject of controversy, was conclusively established by the photographs obtained with the prismatic camera in 1898 and at later eclipses—to the great, though very gently expressed, satisfaction of its author.

Probably next in importance in his work are the observations upon the chromospheric lines, which he began at Dartmouth, and continued on an expedition to Wyoming in the summer of 1872—where, in the clear air at an altitude of 8000 feet, he added 100 more to the list of 190 lines previously observed. These observations were continued at Princeton for many years.

His list of these lines give not only their wave-lengths, but their relative frequencies, varying from 100 for lines which are always reversed at the Sun's limb, to 1 or 2 for those which only occasionally so appear, in regions of great disturbance. It is still the principal authority upon the subject.

In the course of his solar observations he met with many remarkable and unusual phenomena—the highest recorded prominences, distortions of spectral lines, indicating radial velocities up to 500 kilometres per second, and the like. Many of his drawings

of prominences have become classic, from their frequent reproduction.

He was the first to photograph a prominence (in 1870)—though with only partial success, owing to the slowness of the wet plates then used; and in 1876 he made the first use of the grating spectroscope in astronomy, determining the Sun's rotation period by means of the displacement of the lines at the opposite limbs. At Princeton he continued his observations with a much more powerful equipment, and in 1883 he discovered that the background of the spectrum of the sun-spot umbra was not uniformly dark, but, under high dispersion, was resolved into extremely numerous and close-packed dark lines—a difficult observation, now known to be of great importance, in the light of the recent identification of many of these "band lines" with those in the spectra of *compounds* whose existence has been claimed as indicating a lower temperature for the spot than for the rest of the disk.

By no means all Professor Young's scientific expeditions have yet been mentioned. He successfully observed both transits of Venus, in 1874 at Pekin, and in 1882 at home in Princeton. Solar eclipses took him to Denver in 1878, to Russia in 1887, and to North Carolina in 1900. At the second of these bad weather prevented all observations, but conditions were excellent at the other two.

First in importance among his publications is his volume *The Sun*, which appeared in 1881, and has gone through several editions —the last, thoroughly revised, dating from 1895—and has been translated into several languages. It is a standard and authoritative work, covering the whole range of solar physics, so far as it then extended, and giving its author's interpretations of difficult points—which have often been remarkably confirmed by later discoveries—and written in the clear and attractive style which characterises all his productions.

As a writer of astronomical text-books he was unsurpassed, and probably no such works are more widely known, in America at least, than his *Elements of Astronomy*; *General Astronomy*; and the later *Manual of Astronomy*, all of which passed through frequent editions, and were carefully kept up to date by their author until the very close of his life. The accuracy and lucidity of his style are here shown at their best, while the extensive range of his knowledge and his sense of proportion make the larger works very useful as books of reference to many who are no longer counted as students of astronomy in the academic sense.

All who have studied under Professor Young agree that he possessed exceptional gifts as a teacher. His undergraduate lectures were amongst the most popular in the university—not because of any oratorical gifts, nor for the too frequent reason that his examinations were supposed to be easy to pass—but because the clear, well-proportioned outline which they gave of the universe was recognised as a "culture course" of the highest value, and no less because of the personality of the lecturer. Few will forget his

genial courtesy, his individual interest in his students, all of whom, in successive classes, well-nigh a hundred in number, he could call by name, and the quaint New England humour which enlivened his sentences—as when, translating literally from the French, he declared "The Earth's atmosphere is the astronomer's black beast"!

But it was to those who had the privilege of advanced study under his direction that his qualities were most manifest. His extensive knowledge of the whole field of astronomy and of kindred sciences—which even those who knew him well found hard to appreciate, because of the modesty which made him disclaim any exceptional learning—his fairness and sound judgment in matters open to doubt or controversy—the patient care with which he would read and criticise a student's manuscript, suggesting one verbal amendment after another, until one was found which satisfied his exacting sense for accuracy and brevity of expression, combined with good English,—these and many other things made association with him a liberal education indeed.

His scientific attainments won him honorary degrees from several institutions and membership in many learned societies—among them the Royal Astronomical Society, which elected him an Associate 1872 November 8. H. N. R.

Proceedings of Observatories.

Royal Observatory, Greenwich.
(*Director, Sir William Christie, K.C.B., Astronomer Royal.*)

Transit-circle.—During the year 9744 observations of transits and 9469 of meridian zenith distances have been obtained. The Sun has been observed 154 times and the Moon 105 times. The lunar crater Mösting A has also been observed 59 times. Reflexion observations of stars have been obtained on 76 nights.

The improved method of illuminating the field of view which was applied to the Altazimuth in 1907 has now been applied to the Transit-circle, and has been in regular use since April 27. For purposes of comparison two clock stars are observed each night with the old annular illumination. The clock errors, with the new illumination, were $0^{s}\cdot06$ smaller than with the annular illumination until September 17, when a new compound lens was substituted for a simple lens, since which date the difference has been reduced to $0^{s}\cdot02$.

Altazimuth.—This instrument has been used, as before, as a meridian transit instrument during the second and third quarters of the lunation for the observation of the Sun, Moon, planets, and the stars in Newcomb's Fundamental Catalogue. The instrument is reversed every two months alternately by reversing in its Ys, and by turning the instrument through 180° of azimuth.

The total number of meridian transits obtained during the year is 1402, including 72 of the Moon's limbs and 44 of the lunar crater Mösting A. 89 reflexion observations of stars have been obtained. The number of extra-meridian observations of the Moon obtained during her first and last quarters is 35.

During the year arrangements were made for comparing the results obtained with the central object-glass illumination and the annular reflector in the axis; on several fine nights when the instrument was in the meridian some clock stars and standard polars were observed by the latter method. The following differences between clock errors with the two methods of illuminating the field have been found for two of the observers for the period May to September.

Observer.	No. of Nights.	Central Illum.—Annular Illum.
A C	3	$-0^{s}\cdot03$
H F	8	$+0\cdot01$

These comparisons are being continued.

Reflex zenith tube.—During the year 1107 double observations and 14 single observations have been obtained, the brighter stars having been observed over as long periods as possible. γ Draconis was observed on 64 days, β Draconis on 51 days, and ι^2 Cygni on 38 days, and θ Ursæ Majoris on 17 days.

As the arrangement for modifying the illumination of the field by tilting an annular reflector was not satisfactory, a rheostat has been introduced recently for this purpose, and the form of the reflector is being modified, as it was found that part of the pencil of rays for a star at some distance from the centre of the field, such as β Draconis, was cut off by the annular reflector.

Occultations.—During the year 21 disappearances and 3 reappearances of stars occulted by the Moon have been observed by one or more observers. The results have already been communicated to the Society. Both phases of the partial solar eclipse of June 28 were also observed by 6 observers.

28-inch Refractor.—631 double stars were measured during the year; they may be classified as follows:—

83	pairs	under	0″·5 separation
116	,,	between	0·5 and 1″·0 separation
159	,,	,,	1·0 ,, 2·0 ,,
273	,,	over	2·0 separation

κ Pegasi was observed on 9 nights, δ Equulei on 16 nights, 70 Ophiuchi on 21 nights, and ζ Herculis on 14 nights.

The following table shows the number of measures of Jupiter's equatorial and polar diameters with the bifilar and double-image micrometers respectively:—

	Bifilar Micrometer.	Double-Image Micrometer.
Equatorial diameter	640	400
Polar ,,	640	400

The diameters of the four larger satellites of Jupiter were measured on 2 nights.

The new outer dusky ring of Saturn was examined on 13 nights in October and November. Measures of the diameters of the planet and rings were made on 10 nights.

Thompson Equatorial.—A new, faint, and very distant satellite of Jupiter was discovered by Mr. Melotte from photographs taken on February 27 and 28 with the 30-inch reflector, and was afterwards found on photographs taken previously. During the opposition 1907–8 it was followed from January 27 to April 24. The observations show that the orbital motion is retrograde, with a large eccentricity and inclination. It is by far the most distant of the known satellites of Jupiter, and its period is about two years.

In July the 30-inch mirror was dismounted for re-silvering. Advantage was taken of the opportunity to fit into the cell

twelve cast-iron blocks, segmentally shaped, for the purpose of holding the mirror rigidly by means of twelve pushing screws. The result is very satisfactory, the mirror being held quite firmly without any distortion.

In December the mirror was again re-silvered in order to have it in the best condition possible for the observation of Jupiter's eighth satellite and the search for Halley's Comet.

In connection with the photographing of Comet *c* 1908 and in preparation for the search for Halley's Comet, a position micrometer was made and fitted to the guiding telescope of the 30-inch reflector, by means of which the motion of any object may be compensated for whilst guiding on a star. It has proved simple and satisfactory.

Whilst Comet *c* 1908 was under observation, some trouble had been caused on damp nights through the absorption of moisture by the photographic plate (which is quite exposed at the mouth of the 30-inch tube), with a consequent diminution in its sensitiveness. An electric heater was devised which could be put into the plate-holder at the back of the plate. It is successful in keeping the plate dry and there is no apparent falling off in definition due to any air currents.

In December a new central illumination was fitted to the guiding telescope of the 30-inch reflector, similar to that applied to the Transit-circle and Altazimuth.

With the 26-inch refractor the following photographs have been obtained :—

Neptune and Satellite,	29	photographs on	14 nights.
Jupiter for position,	4	,,	4 ,,
Saturn ,,	5	,,	4 ,,

With the 30-inch reflector the following photographs have been obtained :—

Jupiter	VI. Opposition, 1907–8,	31	photographs on	24	nights.
,,	VII. ,, ,,	18	,,	17	,,
,,	VIII. ,, ,,	13	,,	12	,,
Saturn	IX. *Phœbe*,	23	,,	15	,,
Comet *c* 1908 for position,		32	,,	31	,,

In addition 177 photographs of Comet *c* 1908 were obtained on 49 nights, in order to record the changes taking place in the structure of the tail.

23 photographs of the Comet were also obtained, on 20 nights, with a portrait lens (aperture $3\frac{1}{4}$ inches, focal length 11 inches), mounted on the astrographic equatorial.

113 photographs of 38 minor planets have been obtained. These were all taken for determination of position.

Search has been made for Halley's Comet, but so far without success. 9 photographs of the field, with exposures ranging up to 210 minutes, have been obtained.

[Since the date of this report Jupiter's Satellite VIII. has been

picked up again on photographs taken on 1909 January 16 and 19. Its position agrees closely with the orbit computed by Mr. Cowell and Mr. Crommelin.]

The photographs of Neptune and Satellite are measured and discussed as far as the end of the last opposition, and the results published. The photographs of Jupiter's Satellites VI., VII. and VIII. for the opposition 1907–8, of Jupiter for position, of Comet *c* 1908 for position, and of minor planets taken in 1907, have all been measured and published. The photographs of Saturn's Satellite IX., *Phœbe*, and those of Saturn for position have been measured and the results communicated to the Society. Preliminary remarks on the formation of the tail of Comet *c* 1908, as shown on the photographs taken with the 30-inch reflector and with the portrait lens, have been published in the *Monthly Notices*. The measurement and reduction of minor planets photographed in 1908 are in hand.

Astrographic Equatorial.—Work with the 13-inch photographic telescope has been mainly confined to replacing chart plates, which, though satisfactory in other respects, are, owing to slight photographic defects, unsuitable for production of enlarged prints.

During the year, 108 chart plates have been taken and 15 miscellaneous fields. Of the 108 chart plates, 21 were rejected—7 because the exposure was interrupted by cloud, or because they did not come up to the standard in showing faint stars, 7 for defective guiding or wrong setting, and 7 for miscellaneous faults.

Enlarged prints of 193 chart plates have been made and distributed, bringing the total number reproduced to 937, the fourteen zones 65° to 78° and nearly half of the four zones 79° to 82° being complete. There are 212 plates to be reproduced to complete the Greenwich section, and enlarged positives of 140 of these have already been made.

Volume II. of the *Astrographic Catalogue* has been published, which completes the publication of the rectangular co-ordinates of all the stars shown with 6 minutes' exposure in the Greenwich Section Dec. 64° to Pole.

The Standard co-ordinates of the 304 plates in Zone 65° to 68° have been recomputed or revised, using the places of the reference stars given in the *Greenwich Nine-Year Catalogue*, 1900·0. This final computation of constants of plates in Volume I. is complete, except for the re-computation of the constants *c* and *f*.

It was stated in the Introduction to Volume I. that Volume III. would contain a catalogue of certain stars with their positions given in R.A. and Dec. deduced from the measures on the astrographic plates. The computation of these positions is now proceeding and during the year the R.A. and Dec. of 2100 stars in Carrington's Catalogue from the Pole to Dec. 84° and Zone 83°, R.A. 0^h to 20^h have been formed. This work has involved the conversion of the measured co-ordinates of 6300 images. The calculations for the remainder of Zone 83° and for Zone 82°, which contain 770 stars

shown by 1700 images, are completed as far as the formation of standard co-ordinates.

Chart plates for eight fields, to replace slightly defective negatives, now remain to be retaken to complete the chart plates suitable for reproduction.

Photoheliograph.—Photographs of the Sun have been taken on 197 days during the year 1908. Of the photographs, 414 have been selected for preservation, including 26 with double images of the Sun for determination of the zero of position of the wires.

Photographs have been received through the Solar Physics Committee from Dehra Dûn, India, up to 1908 November 28, and these have been further supplemented by photographs from the Observatory at Kodaikánal, India, and from the Royal Alfred Observatory, Mauritius. The daily record thus made up is complete for the year 1908 up to August 18, the date of the last photograph received from Dehra Dûn. The photographs taken at Greenwich have been measured up to 1908 November 25, those from Dehra Dûn up to 1908 September 27, those from Kodaikánal to 1908 June 17, and from Mauritius as far as they have yet been received.

It was discovered in 1907 October that the orientation of the Dehra Dûn photographs was in serious error. It became necessary to reject 215 photographs (155 in 1906 and 60 in 1907) that had already been measured and reduced, and to refrain from selecting for measurement subsequent photographs from Dehra Dûn until the error of orientation had been corrected (1908 February 20). Photographs from Mauritius and Kodaikánal were substituted. The work of the department has therefore fallen into two main divisions, (*a*) ordinary current work, (*b*) the work of substituting fresh photographs for the 215 photographs rejected. On 1908 December 31 these two divisions were in the state of advancement shown in the following tables :—

(*a*) Current work :—

	Photographs from		
	Greenwich.	Dehra Dûn.	Kodaikánal.
Measurement and Reduction to heliocentric co-ordinates	1908 Nov. 25	1908 Sept. 27	1908 June 17
Copy for Press	June 30	April 29	April 11

(*b*) Revision :—Mauritius photographs—

Measurement and Reduction to heliocentric co-ordinates up to	1906 December 11
Copy for press	March 30

Arrangements have now been made for daily photographs of the Sun to be taken at the Cape Observatory, under Mr. Hough's superintendence, to fill up as far as practicable the gaps in the Greenwich series.

There has been a notable diminution in solar activity during 1908, marked, however, by outbursts during April, May, June, August and September.

Owing to a breakdown in health, Mr. Maunder has been absent on sick leave since October 8.

Printing.—The copies of the volume of Greenwich Observations for 1906 were distributed in 1908 September and October, but it is to be observed that the volume for 1906 does not contain the Photoheliographic results, which will be included with those for 1907 in the 1907 volume. This is owing to the discovery of the errors in the orientation of the Dehra Dûn solar photographs to which reference has already been made.

The following special publications were completed early in the year, and were distributed in May and June :—

Astrographic Catalogue, Greenwich section, Vol. II., Heliographic Results, 1874 to 1885 ; *Measures of Photographs of Eros* 1900 to 1901 for determination of the solar parallax.

The printing of the *Greenwich Second Nine-Year Catalogue* (1897 to 1905) is complete, with the exception of the details of proper motions and the introduction, which is ready, and the printing of the Greenwich Observations for 1907 is well advanced.

Capt. C. H. Simpson, R.N., and Capt. C. E. Monro, R.N., with Lieutenant Gibson, R.N., of H.M.S. "Mutine," were attached to the Observatory for some weeks during the year for the determination of the longitude, Greenwich-Ascension-Cape, an account of which has been communicated to the Society, *M.N.*, lxix., No. 1 (1908 Nov.).

Royal Observatory, Cape of Good Hope.
(*Director, Mr. S. S. Hough, H.M. Astronomer.*)

Transit-Circles.—The observations for a catalogue of fundamental stars with the new transit-circle have been continued without interruption throughout the year. The azimuth marks have shown a high degree of stability ; the discrepancies between determinations with Clamp East and Clamp West seem to have entirely disappeared since the alterations in the micrometer referred to in the last report.

Regular observations of the Sun and inferior planets have been continued throughout the year.

The old transit-circle has been used for time determinations and comparisons of personal equation, principally in connection with longitude determinations and the completion of the list of stars, of which places were required in connection with survey operations in South Africa.

The total number of observations secured with both instruments was as follows:—

Observations of Right Ascension :—

	Reversible T.C.	8-in. T.C.
Number of Meridian Transits . .	8902	1174
Determinations of Collimation—		
by collimators	100	5
,, reflexion and reversal . .	46	
Determinations of Level . . .	833	92
Determinations of Azimuth . . .	334	114
Observations of N. Azimuth mark .	1134	
,, S. Azimuth mark .	1145	

Observations of Zenith Distances :—

Determinations of Z.D. . . .	8619	367
Z.D. of N. mark	322	
,, ,, S. ,, ...	322	
Determinations of Runs . . .	378	53
,, ,, Nadir . . .	752	54
,, ,, Flexure . . .	51	11

The observations include observations of the Sun on 135 days, of Venus on 96 days, of Mercury on 53 days.

The lunar crater Mösting A has been observed on 32 nights with the reversible transit-circle, and 21 nights with the old transit-circle.

Heliometer.—The work with this instrument has been confined to the observations of major planets at the time of opposition.

The following observations have been secured :—

Opposition of Neptune . .	36 obs.	on 5	nights.
,, Jupiter . . .	52 ,,	7	,,
,, Uranus . . .	39 ,,	6	,,
,, Saturn . . .	108 ,,	8	,,

The Victoria Telescope.—This instrument has been employed exclusively on the photography of stellar spectra for the determination of velocities in the line of sight.

Observations were made on 165 nights, and 601 stellar spectra were secured. In addition to the plates of stellar spectra, 121 plates of the solar spectrum (daylight) were taken, along with the iron comparison spark, as reference plates for the stellar spectra, as well as 219 focus plates for control of the focal adjustments.

The observing programme for the investigation of the solar parallax was brought to a conclusion in May, and a new programme, embracing the determinations of the radial velocities of 365 stars between + 30° declination and the South Pole, was commenced on July 23.

The spectroscope was dismounted in May for the purpose of altering the adjustment of the slit, which had proved unsatisfactory. New slit jaws were made and fitted, and the micrometric arrangement for regulating the width of the slit was thoroughly overhauled.

Simultaneously, a very thorough examination was made of the optical properties of the lenses and prisms by Hartmann's extra-focal method, as the result of which it has been possible to materially improve the definition and increase the range of the spectrum, through which a sufficiently accurate focus can be obtained.

Astro-Physical Laboratory.—A Hartmann spectro-comparator has been added to the equipment of this department, by means of which the precision of measurement and facility of reduction of the spectrographs have been materially increased. During the year, in addition to 32 plates measured on the Zeiss comparator, 527 stellar plates and 131 solar comparison plates have been measured in this apparatus.

These include 280 star plates and 30 solar comparison plates in connection with the determination of the solar parallax. A discussion of the results of these measurements, which yields a solar parallax of

$$8''{\cdot}800 \quad \pm 0''{\cdot}006,$$

has been passed through the press, and will shortly be issued.

In connection with the examination of the focal adjustments of the spectroscope, 568 focus plates have been micrometrically examined.

Astrographic Telescope.—This instrument has been chiefly used in the photography of selected areas, in accordance with the general plan proposed by Professor Kapteyn. The number of plates secured during the year is as follows:—

Description of Plate.	No. of Plates.	No. of Exposures.	Duration of Exposures.
Kapteyn areas, proper motion plates .	7	14	20^m, 20^m
Kapteyn areas, parallax plates (1st max.) Ilford ordinary plates	19	19	30^m
Kapteyn areas, parallax plates (1st max.) Ilford special rapid plates	61	61	20^m
Kapteyn areas, parallax plates (2nd max.)	88	176	30^m, 30^m
,, ,, ,, (3rd max.)	106	106	30^m
Catalogue plates	11	33	6^m, 3^m, 20^s
Search for Ultra-Neptunian planet .	36	70	30^m, 40^m, 60^m
Adjustments	16	...	various
Encke's Comet	5	5	various

Astrographic Laboratory.—In connection with the Carte du Ciel programme, 128 plates containing 94,052 stars have been measured both in direct and reversed positions of the plates during the year, leaving 110 additional plates remaining to be measured. Rectangular co-ordinates have now been completely reduced and checked for 1173 plates, out of a total number of 1512.

Plate constants have been derived for 295 plates during the year, and applied to the measurements of rectangular co-ordinates on 186 plates.

Occultations.—Twenty-six separate phenomena of occultations have been observed, viz.—

Disappearances of stars at dark limb . .	9
Reappearances „ „ „ . . .	14
Disappearance of Uranus	1
Reappearances „	2

Longitude operations.—By courtesy of the Eastern Telegraph Co., and at the request of the Hydrographer, arrangements were made, on the occasion of the visit of H.M.S. "Mutine" to the Island of Ascension in February, for the exchange of telegraphic signals for longitude both with Greenwich and the Cape. Signals were successfully exchanged on eight nights. The details of the Cape observations have been forwarded to the Astronomer Royal for discussion. A preliminary account of the operations has been communicated to the Society.

Publications:—

Vol. viii. part 1 of the Cape Annals, containing "Heliometer Observations of the Major Planets during the years 1897–1904," and vol. x. part 3, containing an account of the "Spectroscopic Determination of the Solar Parallax," have been passed through the press, and will shortly be issued.

The Cape day-numbers for 1911 have been printed.

Meteorological observations, comprising daily records of air-temperature, pressure, wind, rainfall, etc., have been continued throughout the year, and the results, as in previous years, forwarded to the Meteorological Commission, Cape Town.

Seismograph.—The records of the seismograph have been forwarded to Professor Milne, while a duplicate copy, at the request of the German Government, is forwarded to the Consul-General for Germany in Cape Town, for transmission to the Strassburg central station for the investigation of earthquakes.

Geodetic Survey of South Africa.—The results of the standardisation, at the National Physical Laboratory, of the Russian $2\frac{1}{2}$ metre standard bar, used in connection with the Loangwa Valley base, have been communicated to the observatory, and a definitive reduction has been made of the length of this base. The length, as measured, corresponds so closely with that computed through the triangulation, dependent on bases previously measured in Southern Rhodesia, that no readjustment of the triangulation has been considered necessary. The definitive geodetic co-ordinates of all stations occupied in Rhodesia, referred to the general geodetic system of South Africa, have been computed, and the astronomical observations of azimuth discussed. The preparation of the final report awaits only the discussion of the places of the stars used in latitude observations, the necessary observations for which have been made at the observatory in the course of the year.

Royal Observatory, Edinburgh.
(*Director, Prof. F. W. Dyson, Astronomer Royal for Scotland.*)

With the transit-circle 960 observations were made, completing the observations for the Zodiacal Catalogue. The total number of stars observed for this catalogue is 2713. The reductions are completed and copy for press formed. The publication has been delayed as on some days the number of reference stars is small, but it is hoped to remedy this defect by the use of some stars in Professor Boss' forthcoming catalogue. Professor Boss is kindly arranging to supply the places of the Zodiacal stars in his catalogue in advance of the publication of that work.

For spectroscopic observations of the Sun's rotation, a 9-inch object-glass of 36 feet focal length, with collimator and camera object-glasses of 4 inches aperture and 16 feet focal length, were substituted for the heliometer of 6 feet focus (kindly lent by Lord M'Laren) and suitable collimator and camera in use till the end of 1907. The instrument was mounted on July 2, but not satisfactorily adjusted till the end of August. Good photographs are obtained in the third order on a scale of four millimetres to three tenth metres. Photographs have been obtained on twenty days and are partly measured. Photographs taken on twenty-eight days in 1907 with the heliometer have been measured.

By an arrangement made with Mr. Cooke of the Perth Observatory, Western Australia, this observatory is assisting in the measurement of the astrographic plates of the Perth Zone. As yet only a start has been made; thirty plates in Zone -40° have been measured in direct and reversed positions of the plate: the plate constants have been determined, and the standard co-ordinates of the reference stars computed for the whole zone.

With the 15-inch reflector observations of double stars have been commenced. It is proposed to confine the observations to the part of the sky between the zenith and pole. A working catalogue is being kindly prepared by Mr. Lewis.

Seismographic observations have been carried on continuously, and the results communicated to the Committee of the British Association. Arrangements are being made to obtain the seismographs on a more extended time-scale.

Meteorological observations have been regularly made, including observations of two platinum resistance thermometers sunk in the rock to a distance of 3 ft. 9 ins.

Mr. John Storey was appointed Assistant at the observatory on May 25.

Armagh Observatory. (*Director, Dr. J. L. E. Dreyer.*)

A second supplement to the New General Catalogue of Nebulæ, for the years 1895–1907, has been prepared and published in the Society's *Memoirs*.

Dr. Dreyer is at present engaged in the preparation for the press of all Tycho Brahe's observations of planets and fixed stars from the original manuscripts belonging to the Royal Library of Copenhagen, using also as an occasional check a copy made by De l'Isle early in the 18th century, and kindly lent by the Director of the Paris Observatory. The work is to be published at Copenhagen, at the expense of the Carlsberg Fund, administered by the Royal Danish Academy of Sciences.

Cambridge Observatory. (*Director, Sir R. S. Ball.*)

1. *Meridian Circle.*—During the greater part of the year the observation of Gill's Zodiacal Catalogue of Stars was interrupted by the illness of Mr. Hartley, the assistant in charge of the work, and the instrument was used only for time determination and instruction.

The reductions to apparent place are completed up to 1907 June 19 in Right Ascension and to 1907 December 3 in Declination; and the reductions to mean place are complete to 1907 April 18.

The large volume of Ledger of Observations for the Cambridge Zone Catalogue, now in the press, is printed as far as $8^h\ 18^m$ R.A.

A tape chronograph of new design, with three recording pens, made by the Cambridge Scientific Instrument Company, has been installed. At the same time the Molyneux Sidereal and the Graham mean time clocks have been fitted with contacts by Mr. E. T. Cottingham of Thrapston. The Graham clock is now adjusted daily to G.M.T. The provision of a model time-ball, now in course of construction, will complete the equipment for training students in time-service and telegraphic longitude determinations.

2. *Sheepshanks Equatorial.*—In continuation of the series for stellar parallax, plates were taken by Mr. Hinks, assisted by Mr. Stratton and Mr. Knox Shaw, in the early part of the year. The weather was exceptionally cloudy, and many series were interrupted by failure to obtain plates at the required epoch. About twenty-five series are now complete and ready for measurement and reduction, in addition to those series which are in the hands of Mr. H. N. Russell at Princeton, U.S.A.

3. *Reduction of Eros photographs for determination of the Solar Parallax.*—Good progress has been made in this work during the year. The photographic standard Catalogue of Comparison Stars is complete, and the preparation of copy for press is making good progress. The Catalogue will contain the places of about 7000 stars. A complete copy is being supplied in instalments to M. Gonnessiat, Director of the Algiers Observatory, to serve as a basis for his reductions of the Algiers photographs of the planet. Extensive lists of star places have also been supplied to Professor Hermann Struve, Director of the Royal Observatory, Berlin, for the reduction of his micrometric observations of Eros, made at

Koenigsberg; and to Captain Barnette, U.S.N., Superintendent of the U.S. Naval Observatory, Washington, for the reduction of the micrometric observations made at that observatory.

With the permission of Professor Campbell, Director of the Lick Observatory, the whole series of results obtained from the Crossley Reflector photographs of Eros by Professor Perrine has been communicated in advance of publication, for inclusion in the general solution.

In order to remove certain small defects which had become apparent in the ephemerides of the planet published in Paris Circulars Nos. 9 and 12, M. Baillaud, Director of the Paris Observatory, has kindly undertaken that a new calculation of the whole ephemeris shall be made at Paris, under his direction, by M. Lagarde. This will be ready early in 1909. It will be specially adapted for a new determination of the mass of the Moon, as well as of the solar parallax.

The general solution is making rapid progress, and it is anticipated that the principal results will be ready for presentation to the International Conference of the Carte du Ciel, which meets at Paris in 1909 April.

Mr. Hinks has been assisted in the card catalogue work and in miscellaneous computation by Mr. S. E. Bowd, and the expense of this assistance has been defrayed, as in former years, by a grant from the Government Grant Fund of the Royal Society.

4. *Floating Zenith Telescope.*—The reduction of the observations is very nearly completed, and Mr. Cookson expects soon to be able to publish his results and conclusions as to the instrument and method of observing. No latitude observations have been made since the date of the last report.

5. *Reduction of Lunar Observations.*—Mr. Stratton's work on the lunar libration is nearly completed. Preliminary results were communicated to the British Association in September 1908. The final results will be published shortly.

6. Courses of instruction in practical astronomy, and in field astronomy for surveyors and geographers, have been given by Mr. Hinks during the year.

The Newall Telescope, Cambridge Observatory.
(*Mr. H. F. Newall.*)

Work has been carried on during the past year along three lines of research: stellar spectroscopy, solar observations, and experimental study of spectra in the laboratory.

In the stellar work, the Newall Telescope has been used at intervals in experiments with the diffraction-grating spectrograph. Efforts have been made to develope a method of determining stellar velocities in the line of sight, utilising the sharply defined lines of the α and B groups as standard lines of reference in stellar spectra. These lines are ascribed to absorption produced by oxygen in the Earth's atmosphere, and they appear in the photographs of

the red end of the spectra of all the stars of various types which have been photographed at Cambridge. If a way of utilising them could be practically developed, it would enable observers to secure determinations of stellar velocities in the spectroscopic method without the use of a slit or of a special comparison spectrum. Unfortunately, the result of these efforts is to show that the method is unavailable at present for faint stars, by reason of insufficient sensitiveness of existing photographic plates and insufficient brilliancy of existing diffraction-gratings.

In the solar observations work has been carried on with the Littrow spectroscope and with temporary arrangements of cœlostat and image lenses. Meantime the permanent mounting for the cœlostat has been completely constructed and set up. The new image lens, with an aperture 12 inches and a focal length of 60 feet, is being constructed by Messrs T. Cooke & Sons. The expense of the whole solar installation is being met by appropriations from the Frank McClean Fund. The temporary outfit has been used (i.) in further study of the cyanogen absorption-bands at wave-length 3883 in the solar spectrum, and (ii.) by Mr. Hubrecht in preliminary work on the determination of the rotation of the Sun by the spectroscopic method.

In the laboratory, Mr. Cookson has been investigating the spectra of the electric arc and spark between terminals of various metals, under special conditions, with special reference to the characteristic differences which distinguish the types of stellar spectra. He also continues his work on the aberration constant, and on variation of latitude.

By the generous gift of the Royal Society, the valuable instruments with which Sir William Huggins has carried out his astrophysical researches since 1871 have been presented to the University for inclusion in the astrophysical department. They will form a splendid addition to the instrumental resources of the observatory, and are all the more valued on account of their connection with the historical researches of Sir William and Lady Huggins. A second generous gift has been received from Major E. H. Hills, C.M.G., who has presented his valuable outfit of spectroscopic apparatus, including a four-prism quartz spectroscope, a two-prism flint spectroscope, and a 12-inch cœlostat, of which the mirror was worked by the late Dr. Common.

Dunsink Observatory.

(*Director, Prof. E. T. Whittaker, Royal Astronomer of Ireland.*)

The staff consists, as at the close of the previous year, of the Director and Mr. C. Martin, assistant; the instruments in regular use are the Pistor and Martins meridian circle and the Roberts photographic reflector.

The time-service to Dublin has been continued as in previous years. At present this consists in the control of certain slave-

clocks in Dublin by the M.T. clock of the observatory, and the release of a time-ball at 1·0 G.M.T. In response to a wish expressed by business men in Dublin, arrangements are now being made for the firing of a time-gun at 1·0 Dublin M.T.

350 plates have been taken during the year with the Roberts reflector, which has been employed in variable-star work. A portrait-lens has been temporarily attached to this instrument.

Plans have been prepared for alterations to the dome of the South Equatorial, involving a new dome-shutter.

The professional courses of lectures delivered in Dublin by the Director have been entitled "Cosmical Physics" and "Matter and Radiation." Demonstrations in practical astronomy have been given at the observatory by the Assistant Astronomer; and the South Equatorial has been employed on the first Saturday in each month in showing objects of interest to visitors.

Durham Observatory. (*Director, Professor R. A. Sampson.*)

During the past year, the Almucantar was used on only twenty-six nights, observations being interrupted for some time while the clock was dismounted.

Work on the theory and tables of Jupiter's satellites has progressed rapidly. The whole of the discussion of observations which is to form *Harvard Annals*, 52, part 2, is now in the press: the theory based upon this has been completed, including determination of the masses, and of the long inequalities, and a complete set of precepts has been drawn up for construction of the tables. A great part of these precepts have been calculated, and the tables should be ready for use before next year.

The University has revived the office of Professor of Mathematics and Astronomy, which had been dormant since the death of Professor Chevalier, and has also somewhat increased the allowance for maintenance of the observatory.

Glasgow Observatory. (*Director, Professor L. Becker.*)

During 1908 the director and his assistant have devoted a great portion of their time to preparing the forty years' meteorological records for the press. The observing work, detailed in former reports, has been continued with transit-circle and spectrograph on the few favourable nights available in this manufacturing city. The University authorities have now approved of the erection of an observing station at some distance from the city, provided that the necessary funds can be raised by subscription.

The time service and the meteorological observations have been carried on as in former years.

Liverpool Observatory. (*Director, Mr. W. E. Plummer.*)

The character of the work of the observatory during the past year has remained unchanged. The transit instrument and the equatorial have been kept steadily at work, and the number of observations has been practically maintained, though the number of observing nights has been rather less than in former years. The results of the meridian observations have been used entirely to ensure the accuracy of the distribution of time signals, the instrument possessing sufficient accuracy for this purpose. The extra meridian observations have been confined chiefly to comets; and though a very good series of measures has been obtained of Comet Morehouse, the number of comet observations is less than usual. As in former years, the position of the components of some well-known binaries has been observed. The registration of unfelt Earth tremors by the Milne seismometer and the meteorological work, together with other matters of routine, proceed as usual. Courses of lectures in connection with the Liverpool University have been given as in former years.

Radcliffe Observatory, Oxford.
(*Director, Dr. A. A. Rambaut, Radcliffe Observer.*)

Early in the year the exposures necessary to complete the parallax investigation, as arranged in consultation with Professor Kapteyn, and described in previous reports of this observatory, were successfully made. Particulars as to the regions of the sky included in the programme of operations, and of the state of this work at the beginning of 1907, will be found in the Report of the Council for that year.

Two photographs of the region surrounding the star *B.D.* $+44^{\circ}$, 1408 (one of the selected fields), were sent in January to Professor Kapteyn for measurement. These plates were selected for special investigation at Groningen, for the reason that on one of them the images were found to be surrounded with a curious white fringe or aureole which it appears arises sometimes from a slight dewing of the objective. The results obtained from these plates must therefore not be taken as indicating the extreme limit of accuracy attainable in parallax determinations by Kapteyn's method as applied to the Radcliffe 24-inch telescope. The results of the measures of these plates made at Groningen are, however, very satisfactory, and show that the probable error of a parallax as deduced from a plate to which a triple exposure has been given at each of three seasons of maximum parallax factor is about $\pm 0''{\cdot}017$.

The remainder of the parallax plates will be measured at the Radcliffe Observatory. During the year satisfactory progress has been made in this direction with the new Grubb measuring machine, and already a large number of such measures has been accumulated.

The conclusion of the parallax work with the 24-inch telescope has afforded an opportunity for having some small additions and modifications made to this instrument which experience showed to be desirable before commencing the investigation of proper motion of faint stars to the 14th. magnitude, to which the instrument is to be devoted for some years to come.

This telescope has also been employed for photographing the fields containing the variable stars 31, 1907 Aurigæ and 89, 1906 Draconis, and for other miscellaneous observations.

The 18-inch visual telescope, when not in use as a guider to the 24-inch, has been employed for various purposes, *e.g.* the examination of Saturn's rings about the time of their edgewise presentation, and observations of Morehouse's Comet.

The 10-inch Barclay equatorial has been used for various observations of a miscellaneous character, including—

(1) Partial eclipse of the Sun on June 28th.—also observed with the $3\frac{1}{4}$-in. Marlborough telescope.

(2) Examination of Comet Morehouse (*c* 1908).

(3) Examination of the visibility of Saturn's rings.

(4) Magnitude of the variable star 31, 1907 Aurigæ.

(5) Determination of the value of the screw of the Grubb bifilar micrometer.

Observations have also been made with this instrument, on his own initiative, by Mr. Barrett, as volunteer work, on the following objects:—The variables RW Draconis (observed on 18 nights right through the maximum phase), ST Draconis (182, 1907), and Lacertæ (10, 1908), Saturn's satellites, Rhea and Dione, etc.

In the computing department attention has been chiefly directed to the meteorological reductions, and to the measurement of barograms and thermograms for the years 1900–1903 inclusive. The micrometer measures of Daniel's Comet have been reduced, and the results published in *M.N.*, lxviii. 8. Time has also been devoted to examining the original records of Main's observations to explain a few additional discordances pointed out by Dr. Ristenpart between the places published in the Radcliffe volumes and those of the A.G. Catalogues.

Meteorological and earth temperature observations have been made regularly on the same lines as heretofore. The latter will be discontinued at the end of the current year.

University Observatory, Oxford.
(*Director, Professor H. H. Turner.*)

Volumes iii. and iv. of the Oxford Astrographic Catalogue were distributed during the year. Volume vi. is completely printed and will be issued shortly. It contains the places of 71,035 star images on 180 plates with centres in $+26°$ declination, and covers the region $+25°{\cdot}0$ to $+27°{\cdot}0$. Thus places are now printed for stars in any part of the zones ($+31°{\cdot}0$ to $+25°{\cdot}0$) assigned to Oxford,

though the portion $+28°{\cdot}0$ to $+25°{\cdot}0$ has only been covered once. Volumes v. and vii. will give a second position for stars in this portion; but the printing of volume v. was deferred until after vi. for the reason indicated. The rate of printing two volumes a year has not been maintained owing to several causes: the dismounting of the Equatorial, and consequent interruption of work in the winter of 1907–8, the absence of Mr. Plummer in America, and the larger amount of revision required by the earlier work, which has been further increased by failures in sensitiveness of plates taken for revision.

This revision involves the taking of new plates in cases where the number of stars on those already taken fell seriously below expectation; and consequently there are in the Observatory measures of a certain number of stars on two plates of the same region taken at an interval of some years—15 years in some cases. As the result of a conversation with Professor Kapteyn, these measures are being compared with the view of detecting large proper motions; but experience shows that the number of such large P.Ms. of faint stars is very small (*Monthly Notices*, lxix. p. 57).

Mr. Plummer returned to the Observatory in October, after an interesting and profitable experience at the Lick Observatory.

Pogson's Observations of Variable Stars, prepared for publication as vol. lviii. of the *R.A.S. Memoirs* by Mr. C. L. Brook, with an introduction by the Director, were published during the year. There still remains much work to be done in preparing Baxendell's Observations for press.

The Director accepted an invitation from the Egyptian Government to report upon the capabilities and use of the 30-inch reflector recently presented to the Helwan Observatory by Mr. J. H. Reynolds, and was at Helwan for that purpose from 1908 December 26 to 1909 January 10.

In connection with the I.U.S.R. Computing Bureau, two notes on the position of the Sun's axis of rotation have been published in the *Monthly Notices*, and a third is nearly ready. A brief investigation of possible oscillations in the epoch of maximum was also carried out (*Monthly Notices*, lxviii. p. 656).

Temple Observatory, Rugby.

This observatory has been used for scholastic purposes as usual, and the attendance of boys has been considerable. In spare time the measurement of double stars has been continued, as in former years.

Solar Physics Observatory, South Kensington.
(*Director, Sir Norman Lockyer, K.C.B.*)

Observations of Sun-spot Spectra.—During 1908 the Sun was visible on 231 working days, observations of sun-spot spectra being made on 62 days, and 123 spots being examined in the region

F–D. The chief widened lines are still those due to Vanadium, Titanium, Scandium, and to Magnesium associated with Hydrogen.

Attempts were made during the year to bring into use the large Kensington Sun-spot Spectrograph, which was described in some detail in the last Report. The object of the work was to determine the difference, if any, between the spectrum of the general solar disc and the regions of the spot zones. Owing to the size of the instrument and its proximity to a main road, it is very subject to vibration, hence long exposures were impossible, and the investigation had to be reluctantly discontinued.

Spectroheliograph.—The weather conditions as experienced at South Kensington during 1908 were not very favourable for observations with this instrument, though fine enough on 126 days to warrant attempts being made to secure photographs of the Sun in "K" light. During the year 420 negatives showing the distribution of "K" light on the Sun's disc, and, using an occulting disc over the primary slit plate, 55 negatives showing the prominences were obtained. On most of these latter the structure on the disc was also photographed. On account of the feebleness of the sunlight and the position of the Sun among high buildings and trees, the instrument cannot be effectively used during the winter months.

The arrangement with the Indian Government as to exchange of spectroheliograms between Kodaikánal and South Kensington continues. During 1908, 251 plates showing the Sun's disc in "H" and "K" lights have been received from Koidaikánal. These were taken during the period October 1st, 1907, to June 30th, 1908. From South Kensington 55 glass positives of the Sun's limb and disc in "K" light were forwarded to Kodaikánal during the year.

In order to complete the spectroheliograph record for 1906, M. Deslandres, of the Meudon Observatory, has kindly forwarded glass positives for seven blank dates, and has promised future help.

A further promise of assistance in the completion of this series has been received from the Observatorio del Ebro. Here, however, the records only date from 1907, as before then the photographs were not regularly obtained.

With the same object in view, Professor Hale has been written to, but up to the present there has scarcely been time for a reply from him.

The measurement of the series already available is being rapidly pushed forward, and, though, for many reasons, the work is difficult, the agreement between the two observers on the work is very satisfactory. The comparison of the areas of the flocculi thus obtained with the sun-spotted areas shows a close agreement between their variations. This suggests the value of the spectroheliograph records for bridging the almost spotless periods of sun-spot minima.

Sun Photographs.—Daily photographs (glass negatives) of the Sun's disc are received from Dehra Dûn (India) and from Mauritius, the gaps in the Indian record being filled up as far as possible by negatives from Mauritius and Greenwich. The negatives are forwarded to Greenwich for measurement and reduction as they

are required. Positives on paper are also received. These are mounted on cartridge paper and bound up into half-yearly volumes for ready reference. Since the beginning of 1906, enlargements of spectroheliograms, when possible, have been mounted alongside the paper prints for comparison.

Night Work.—The weather conditions for night observations have not been good. Really first-rate nights suitable for the best photographic work have been very rare. Few opportunities were found for making effective use of the 36-inch reflector, though it has been kept constantly in excellent adjustment; however, two fairly satisfactory spectra of the Orion Nebula were obtained, while photographs of the region of Comet 1908 (*c*) were secured on the following dates:—October 1, 10, 14, 15, 17, 21; November 7, 12, 14, 18, 23. Visual observations of the spectrum of the comet were made on two occasions.

With the 6-inch Henry prismatic camera 32 photographs of ten stellar spectra have been taken during the year. The 10-inch refractor, on which the above prismatic camera is mounted, has been used, when possible, for obtaining the position and making visual observations of Comet 1908 (*c*).

The 2-inch quartz-calcite prismatic camera still continues in use to determine the relative extensions, in the ultra-violet, of the spectra of pairs of stars, and thus to infer their relative positions on the temperature curve in the South Kensington stellar classification. Seventeen pairs of stars have thus been photographed under conditions as nearly alike as possible for each member of the pair. With the 6-inch Dallmeyer camera, on the same mounting, photographs of Comet 1908 (*c*) have been obtained on the following dates:—September 15, 29, 30; October 10, 14, 21, 23, 27, 29.

Publications. — Papers dealing with prominence and coronal structure, the observation of Sun and stars in some British stone circles, the general spectra of certain type stars, the spectra of several of the brighter stars in the green region, and monthly mean values of barometric pressure for 73 selected stations, have been published during the year. Papers relative to the spectra of the Sun, chromosphere and the lower type stars in relation to the sun-spot spectrum, also a discussion of Australian meteorology, and an account of certain lines occurring in celestial spectra, are ready for publication or in the press.

Royal College of Science, South Kensington.
(Assistant Professor A. Fowler.)

The observatory work, apart from the instruction of students, consisted chiefly of observations of the spectra of sun-spots and eruptive prominences. The sun-spot spectra were apparently identical with those observed during the previous four years, and dark D_3 in the circumpenumbral regions continued to be a frequent feature. In the case of prominences the bright lines noted were also practically identical with those previously recorded.

The varying spectrum of scandium under different experimental conditions has been investigated in relation to the Fraunhofer lines, the spectra of sun-spots, and the spectra of prominences. The rare material required for this research was very kindly provided by Sir William Crookes (*Phil. Trans.*, vol. 209 A, p. 47). Work on other substances is in progress, and measurements of the complex spectrum of magnesium hydride are nearly completed.

The equipment of the laboratory has been extended by the addition of a concave grating of 10 feet radius, and a 5-kilowatt high-tension transformer, adjustable to ten, twenty, or forty thousand volts.

Stonyhurst College Observatory.
(Director, Rev. W. Sidgreaves.)

Progress in astrophysical work has been greatly retarded by continuous cloudy weather. But the number of solar drawings is but little below the average.

Amongst the few stellar spectrographs obtained on Messrs. Wratten and Wainright's panchromatic plates, those of γ Cassiopeiæ show H_α the strongest of bright hydrogen lines. And on the only plate of o Ceti (October 24), H_β is stopped out by the neighbouring absorption-band, and H_α is most probably masked by the excessive brilliancy of the red region of its spectrum; all the absorption-bands are well shown, but in other respects the photograph is very poor, and nothing can be made of the line spectrum for comparison with the spectra of β Pegasi and α Orionis, which are now complete up to H_α.

Comet Morehouse 1908 has been photographed on every available night between September 29 and November 29, furnishing a series of 28 plates on 20 nights. Some of these are weak, taken between passing clouds and through much haze, but only one exposure was a complete failure. Several in clearer sky show well-defined details. All were taken with the Whitelow camera (Dallmeyer 6-in. portrait lens).

The solar grating-spectrograph has been in use whenever possible; but always, until quite recently, under difficulties with the clock gear working the heliostat; and several photographs of the spectra of the larger spots have been secured.

Considerable time has been devoted to an examination of our 30 years' series of magnetographs in connection with solar influence. This has been carried down to the year 1889, with the preliminary results of many well-established recurrences of disturbances at 24-hour intervals, and of over 70 per cent. of all disturbances, great and small, occurring during the Greenwich night hours between 7 P.M. and 3 A.M., with a maximum frequency between 9 and 11 P.M.; raising the question whether this indicates a greater sensibility to solar influence of some region of the Earth in longitude 10 hours west of Greenwich. But the work was unavoidably suspended in September, and has not yet been resumed.

Dr. Doberck's Observatory, Sutton, Surrey.

A $7\frac{1}{4}$-inch equatorial telescope was erected by Messrs. T. Cooke and Sons, of Buckingham Works, York, in an observatory built by the Berthon Boat Co., Romsey, Hants. It was ready for use on the 25th April 1908. The object-glass is of the finest quality: bright double stars with a distance of $0''.3$ between the components are seen elongated.

With the co-operation of Mrs. Doberck, 939 measures of double stars had been secured by the end of the year, but the final value of a screw-revolution has not yet been fixed, as this instrument (like the one at Markree used by the writer 1875–1883) is not suited for the determination of this value by transits without sacrificing several fine nights. It is being determined by the measure of large arcs in the sky. The working catalogue has been supplemented by objects taken from Burnham's great general catalogue, and contains now almost 800 entries. Use is also made of Mr. Maw's excellent suggestion to observe the position-angle of stars placed at right angles to the wires.

A paper was published on the 26th. April 1896 in *Ast. Nach.* No. 3370 on the probable errors of double star observations made by different observers. This has been followed by over thirty papers on the same subject, and the average results are published in *Ast. Nach.* No. 4229. As stated in that paper, the writer is continuing and extending these researches on the basis of other data than those used in that paper. Papers on the hypothetical parallaxes of double stars, and their connection with the elements of the orbits and also with proper motion, were published in the *Ast. Nach.* Nos. 4271 and 4291. An orbit of γ Virginis was published in *A.N.* No. 4235. As perturbation of the elliptic motion is indicated, this star is still under investigation, as well as α Centauri (*A.N.* No. 4189) and ζ Aquarii. The writer suspects that one of the components of the latter has a very close companion. The orbit of λ Ophiuchi has been computed, but the result is different according as the angles or the distances are represented by the orbit: they cannot both be represented at the same time. However, the components differ greatly in brightness, which may account for a portion, if not the whole, of the difficulty. A paper on ζ Cancri C (*A.N.* No. 4273) proves this star to move round an invisible companion, as maintained by Seeliger against Burnham. The existence of the invisible star is indicated by Burnham and Barnard measures instituted to settle the question. The poles of the orbits of double stars have been investigated by the writer for over thirty years. In a paper in *A.N.* No. 4291 it is indicated that they are scattered at random. New orbits have been published also for 42 Comæ Berenicis (*A.N.* 4276), η Cassiopeiæ (*A.N.* 4296), and γ Coronæ Borealis (*A.N.* 4296). An orbit of the latter is being calculated by the method of least squares from both angles and distances.

At the time of his discovery of double stars, Sir William Herschel estimated the distances between the components in star diameters. These records have now been reduced. Herschel's observations in case of stars below 2″ in distance are more accurate than any made before W. Struve commenced to use his 9-inch equatorial, but above 3″ they are not accurate. A paper on the subject is now in the press.

The co-ordinates of the observatory are: — longitude $0^h\ 0^m\ 44^s{\cdot}53$ W., latitude 51° 22′ 19″·8 N., altitude 167 feet above M.S.L. The geographical co-ordinates were determined by the Ordnance Survey, the altitude by the writer.

Wolsingham Observatory (*Rev. T. E. Espin's*).

The work of measuring Sir John Herschel's double stars in the selected zones has been continued during the year, and also of measuring various miscellaneous pairs. The search for new pairs has also been continued, and the results communicated to the Society.

Mr. Franklin-Adams' Astrographic Laboratory.

All possible work, even routine work, not absolutely necessary, was suspended in the autumn in order to make sure of the completion of the 412 charts before October 7th., the first day upon which the completion could reasonably be expected: not only was this not accomplished, but on the 31st. December there still remained twenty regions to photograph. Every hour of every night has been watched, but spells of $2^h\ 20^m$ have been few and far between; the British climate is very trying for a series of long exposures on the meridian; the 200 plates were begun in October 1904 and are still unfinished; one great hindrance has been dew on the object-glass. Upon one night in November, which was truly magnificent, five plates—a record—were all spoilt by dew. A long search in the Library of the Royal Institution and many inquiries from friends yielded no information as to dew precaution; experiments were then started, and it is believed that these have been perfectly successful. The writer hopes shortly to communicate this success to the R.A.S.

Collotype proofs are now being prepared of a pair of charts for distribution to observatories and libraries, with a view of ascertaining the demand for complete sets of collotypes at the price of printing, distribution, and materials.

The production of the necessary positives for this work has entailed months of labour in experiments, no precedents having been found for such star-work upon plates of 15 inches × 15 inches, the difficulty being even coating in wet collodion or emulsion; at the time of writing a Taylor & Hobson Cooke lens is being tried, with exposure to fifty filament metallic lamps.

The problem is to combine sufficient density with the non-obliteration of stars between 13 and 14·5 magnitude. The collotype process then loses more stars, and the writer is being urged in the most influential quarters to publish the collotypes as an atlas, and sun-prints for the investigation of star distribution. He hopes to have this question discussed at the Paris Conference in April.

An experiment made at the time of closing this report may be of interest to magnitude observers, and will show the sort of work being done :—

A square degree in the centre (and best part) of chart No. 147, $7^h + 30^\circ$ (galactic latitude + 16°·9), yields the following number of stars :—

The negative gives	1276 stars	with a limiting mag. of	14·7
„ Contact print gives	1210	„ „	14·5
„ Camera „ gives	1158	„ „	14·4

The average loss on the positives will probably be rather more than this. The smaller number upon the camera print probably means that the focus of the copying lens is not perfect.

The plate covers 225 square degrees, plus about 75 square degrees of duplicate overlap.

Sir William Huggins' Observatory, Upper Tulse Hill.

During the past year work has been continued in the laboratories on terrestrial spectra, for the purpose of supplying material for a fuller discussion and interpretation of the spectra of the heavenly bodies obtained in the observatory.

Mr. Newbegin's Observatory, Sutton, Surrey.

Sixty-seven observations of prominences were made in 1908 during the months January to December. The number of prominences recorded was 599, one of which (July 1) was marvellously active. Both the C line and D_3 were many times reversed and affected. The Southern Spot Zone seems to have been most favoured in prominences.

Twenty-two sketches of Jupiter were made, which indicated some interesting details in the region around the red spot. The Director of the Jupiter Section of the British Astronomical Association, the Rev. T. E. R. Phillips, selected one for the recent Exhibition at Shepherd's Bush.

Rousdon Observatory, Lyme Regis, Devon.
(Sir Wilfred Peek's ; C. Grover, Observer, in charge.)

The exterior of the observatory has been repainted during the summer, and the astronomical instruments are in good working order. Weather generally has been favourable, particularly from

July to October, during which period about half the nights were available for observation, and 1908 shows a considerable increase over 1907 both in night work and in number of magnitude determinations. Observations were made on 145 nights in 1908, and 445 magnitude determinations were recorded, making a total of 10,520 magnitudes during the twenty-three years this work has been in progress. Agelander's method is followed: each observation consists of the mean of five visual comparisons of the variable, with five other stars whose magnitudes have been carefully determined, and all comparisons are made with stars in the same telescopic field as the variable. In nearly all these observations the tables of comparison stars, with their photometric magnitudes as furnished by the Harvard College Observatory, have been used.

The instrument in use throughout has been the 6·4-inch equatorially mounted Merz refractor, the powers mostly used being 34, 80, 132. A 13th. magnitude star is about the limit of vision with this telescope.

Comet *c* 1908 (Moorhouse) was first observed here September 24, and was last seen December 11, having been followed for two months and seventeen days. Although it was only faintly visible to the naked eye, it was a most interesting telescopic object, and the emission of successive clouds of luminous matter from the head which were such a striking feature of the Greenwich photographs could be well seen visually, and as late as November 22 three of these luminous clouds could be distinctly observed.

The transit instrument has been used as required for the regulation of the sidereal clock.

Mr. Saunder's Observatory, Crowthorne, Berks.

The principal work has been in connection with the measurement and reduction of two Yerkes negatives of the Moon. The reductions are now completed, and it is hoped soon to commence preparing the results for publication.

The Observatory of the Egyptian Survey, Helwan. (*Director, Mr. B. F. E. Keeling.*)

Work at this observatory has in the past been chiefly meteorological, magnetic, and geodetic, though time observations are made, and some other astronomical work has been done. But a 30-inch reflector has been presented to the observatory by Mr. J. H. Reynolds (see *Monthly Notices*, lxvii. p. 447), and Mr. Knox Shaw has recently been appointed astronomical assistant, with special reference to this gift. Professor Turner visited the observatory at the end of 1908 and discussed a programme of work. It is hoped that by the time of the next Annual [illegible] a satisfactory start may have been made in the photogra[illegible] nebulæ between 0° and −40° Declination.

Kodaikánal and Madras Observatories.
(Mr. C. Michie Smith, Director).

The year was on the whole a favourable one for solar observations. July and October were less favourable than usual, but November, which is usually a bad month, was abnormally fine.

Photoheliograms were taken on 338 days, and 12 negatives for 1908, 3 for 1907, and 30 for 1906 were sent to Greenwich to fill up blanks in the Greenwich-Dehra Dûn series of solar photographs. A number of large scale photographs of individual spots, many of which show much detail, were taken during the year.

Spots were observed on 344 days, and their positions were approximately determined by projection. The number of new groups observed was 262, with a mean daily number of 3·9 against 301 groups with a mean daily number of 4·6 in 1907. Spots were much more numerous in the southern than in the northern hemisphere. On four days the Sun's surface was quite free from spots at the time of observation.

Spectroscopic Observations.—Prominences were observed and drawn on 310 days, and observations were made of the bright lines in metallic prominences. Sun-spot spectra were studied in detail in the part of the spectrum for which this observatory is responsible to the International Union for Solar Research. Photographs of spot spectra were taken when possible, and much work has been done on the investigation of such questions as the rotation velocities of the higher gases of the chromosphere and of quiet prominences, the relative shift of certain lines in spot and limb spectra, and the cause of the shift towards the red of the lines at the Sun's limb.

Spectroheliograph. — Spectroheliograms were taken on 337 days, but on 42 of these the results were not altogether satisfactory on account of unfavourable weather. Several notable eruptive prominences were photographed during the year, and the rapid changes in their forms were followed in a number of successive photographs at short intervals.

Publications.—Bulletins Nos. xii. and xiii., dealing with the prominence record, were published during the year.

At Madras, observations were as usual confined to those required for the efficient maintenance of the time service. At the close of the year a new dome was erected over the 8-inch equatorial, and it is now again possible to use this telescope.

Perth Observatory, Western Australia.
(Director, Mr. W. Ernest Cooke.)

On 1908 January 1 all meteorological work was transferred to the Commonwealth, and the observatory has at last become a purely astronomical institution. The permanent staff now consists, besides the Director, of only two transit observers and computers and one astrograph observer, who is also instrument-fitter and

photographer. Four young ladies are temporarily occupied in measuring the photographs With such a small staff, it is evident that very little can be done beyond the essential work in connection with the International Astrographic Catalogue. All the plates have been already taken, but, upon careful examination, some have to be rejected, and the region re-photographed. This is being done as occasion arises.

During the year steady progress was made in measuring the plates, and the zone 32° is now completely measured in direct and reversed positions, with the exception of 39 regions which have to be re-photographed. Plate-constants have not yet been determined, because, as explained elsewhere,* it was considered advisable to re-observe the reference stars with the transit circle, and this has been the principal occupation of the transit observers during the year. It is proposed to publish, instead of measured diameters, the actual magnitudes of the stars. The first volume of the Astrographic Catalogue is therefore not yet quite ready for the printer, but hopes are entertained that publication may be commenced before the end of next year.

The first five months were occupied by the Director and the two transit observers in magnitude-equation and experimental work. Then one of the latter took a long-service holiday. Notwithstanding these drawbacks, the meridian observations have progressed most satisfactorily since they started on May 29. The working list embraced all the reference stars of zones 31° to 33°, of each of which three complete observations are required. In addition, a special effort was made to pick up a number of observations of zones 33° to 35°, which had been missed last year owing to abnormal cloudiness and other causes. Every conceivable labour-saving device has been employed, and the assistants have been most enthusiastic, with the result that, with very few omissions, they have kept pace with the programme, and the reductions are practically up to date.

The Director has been comparing the results of 33° to 35° observations with the "Perth Catalogue of 420 Standard Stars," and determining and applying corrections in the manner described on p. 5 of Perth Catalogue, vol. ii. This is not yet completed, and, in fact, it will be necessary to re-observe a few selected stars to act as secondary standards, but it is hoped that "Vol. iii. Meridian Observations between 33° and 35° S. Declination" will be printed and distributed in a few months' time.

The astrograph is used partly for re-photographing rejected plates and partly for entertaining and instructing visitors. At least four or five nights are devoted every month to the latter purpose, and the visitors' evenings have always been fully engaged for three months in advance ever since the observatory started. This may seem, to older institutions, a curious practice, especially as the "working" eyepiece, with all the scales, lamps, etc., has to be exchanged each time for a "visitors'" eyepiece; but it appears to

* Introduction to "Perth Meridian Observations," vol. ii.

be necessary under the circumstances, and is undoubtedly fostering an interest in astronomy, which a short time ago was lacking.

Since, however, only one assistant can be spared for the astrograph, and most of his time is devoted to duties of a mechanical nature, it is obvious that there is no present prospect of any contribution from this observatory to the long-exposure charts.

The following is a résumé of the work done during the year in connection with the Astrographic Catalogue :—

Plates completely measured in direct and reversed positions,		124
No. of stars measured		49,108
Plates rejected and retaken		44
Nights on which time was determined		220
Observations of clock stars in R.A.		1,032
Observations of zone stars in R.A.*		4,589
,, ,, in N.P.D.*		4,581
Separate determinations of	Collimation error	6
	Level error	184
	Azimuth error	138
	Nadir point	160
Readings on meridian mark		18

The Second Meridian Catalogue, giving the positions of 1625 stars between 39° and 41° south declination, was printed and distributed during the year.

Astronomical Field Work.—An important geodetic station, Mount Maxwell, was established during the year. This hill has an altitude of 1350 feet, and is situated about 17 miles east of Perth. It commands a view of several coast and inland trigonometrical survey stations, and serves as a connecting link between the two systems. Owing to certain anomalies in the direction of the vertical, the Surveyor-General requested the Director to ascertain the astronomical difference of longitude between Mount Maxwell and the observatory. Unfortunately the new station is miles away from any telegraph line, so a portable acetylene lamp was placed inside a box, in the front of which a photographic camera shutter was mounted. By standing in front when setting the shutter, and stepping aside when squeezing the pneumatic release, series of sharp flashes were given from either end alternately. Somewhat contrary to expectation, it was found that it was possible to determine differences of time by this rough apparatus with considerable accuracy. The almucantar method of obtaining time with the 12-inch theodolite was, as usual, adopted, and the resulting difference of longitude on four separate evenings was

m	s
1	8·36
	8·27
	8·27
	8·29

* Since 1908 May 29.

The adopted difference, giving greater weight to the two best nights, was $1^m\ 8^s{\cdot}31$. As a check, the bearing of one station from the other was carefully determined from each end, and the discrepancy between these gave another means of obtaining the difference of longitude, which worked out as $1^m\ 8^s{\cdot}33$. It is probably unusual to determine differences of longitude by azimuth determinations from each end, but this would appear to be an alternative method of considerable utility under certain circumstances.

Melbourne Observatory. (*Director, Mr. P. Baracchi.*)

The only astronomical work done at this observatory in the year 1908 comprises Meridian observations, and the measurement of Astrographic plates.

The Meridian observations, shown in the table below, were made, as usual, with the 8-inch transit-circle by Troughton & Simms.

	Observations in R.A.	Observations in N.P.D.
Clock stars	1042	102
Azimuth stars	432	180
List stars	936	990
Totals ...	2410	1272

The list stars were selected, as in previous years, from the plates of the Astrographic Catalogue, which are to be used as standard stars for the determination of plate constants. Of these only 435 now remain to be observed to complete the whole series required for the Melbourne Zones, and it is expected that this will be done during the current year. The Annual Catalogue for 1907 has been prepared, and the reductions of the observations made in 1908 have been so far advanced as to be nearly ready for the preparation of separate results.

Mr. C. J. Merfield, who was appointed Second Assistant to this observatory last June, and took up his duties on 1st. July, has been in charge of this work, assisted by Messrs. Moroney and Woodhouse, two junior observers, who were permanently appointed in May 1908, after some preliminary training in Meridian observations and computations. They all give good promise to maintain the same standard of accuracy which has always been aimed at in this observatory in this class of work. The measurement of Catalogue plates of the Sydney and Melbourne Zones has been continued throughout the year by the Measuring Bureau, established and maintained at this observatory at the joint expense of the Governments of New South Wales and Victoria. It consists of six ladies, with the addition of Mr. G. F. Johns, formerly of the Greenwich, Cape, and Perth Observatories, who has been employed as a temporary assistant since March 1908.

The numbers of plates measured are—

5 Sydney plates, containing 5,653 stars,
256 Melbourne plates, containing 85,146 stars.

The following numbers of plates completely measured show the state of the work up to December 31, 1908 :—

705 Sydney plates, containing 428,206 stars,
1,149 Melbourne plates, containing 369,730 stars.

As regards the Melbourne Astrographic Zones, all plates of the Catalogue series have been taken and measured, and the two series of chart plates, with single and triple exposures respectively, have also been taken, in accordance with the original programme.

It is intended, however, as stated in last year's report, to continue and complete the duplicate series of Catalogue plates, and to extend the triple exposure series to the zones with centres at even degrees of declination, so as to twice cover the whole area from $-64°$ to the South Pole.

The Government is now being urged to grant means for commencing the publication of the Astrographic Catalogue as soon as possible; but it has not been deemed opportune to take, as yet, any steps in regard to the reproduction of the chart plates.

The following routine duties and miscellaneous work were carried out for local public requirements as usual :—

The Time Service, including daily time signals, control of public clocks, and rating of chronometers for the shipping.

The testing of nautical, meteorological, and surveying instruments.

The technical operations of the Bureau of Standard Weights and Measures according to law.

The continuous registration of the variations of sea-level, atmospheric elements, seismic disturbances, and the elements of terrestrial magnetism, including the reduction of magnetic records of past years.

I am pleased to report that Mr. J. M. Baldwin, who has been appointed Chief Assistant to this observatory, returned to Melbourne and took up his duties here last November, after having spent over two years at the Cape and Potsdam Observatories, and having visited all the principal Observatories of Europe and America.

Sydney Observatory. (*W. E. Raymond, Officer in Charge.*)

During the year 1908 the number of observations taken comprised :—

For R.A. observations of stars . . .	973
„ N.P.D. „ „ . . .	754
„ R.A. „ of Sun . . .	476

making a total of 1449 R.A. observations.

The 9 A.M. Collimator, Level and Nadir readings . 313 of each
The 9 P.M. Level and Nadir observations . . 63 „
Azimuths determined from 60 pairs of Circumpolar stars.

The definition for astronomical work has been very bad during the year, in fact the worst the writer has seen during his seven

years as an observer here, and this fact emphasises the necessity for the removal of the observatory to a clearer atmosphere.

1079 visitors have registered their names during the year, of whom 427 attended in the evening. Lectures were given with the large equatorial telescope, or lantern, occupying in all 45 nights.

The astrographic work at Red Hill Branch was continued by Mr. J. W. Short, Astronomical Photographer. Owing to cloudy weather and the absence of that officer at the Solar Eclipse Expedition to Flint Island, photographic results have not been as satisfactory as in other years, four months having been practially lost owing to rain and clouds. But the good quality of the work has been maintained. The plates taken comprise 120 chart plates, 6 catalogue and 3 test plates. In addition, magnetic observations were made each month during the year.

Mr. W. C. Graham has, in addition to his ordinary duties, had charge of the Milne Seismograph, and has recorded 90 earth tremors. They have been all measured and tabulated, and the reports forwarded to the Seismological Committee of the British Association for the Advancement of Science.

The Mechanician, Mr. W. I. Masters, has had charge of the instruments, and his duties have been carried out as heretofore.

The death of the late Government Astronomer, Mr. H. A Lenehan, after an illness extending over four months, is recorded with the deepest regret.

On June 30th Mr. C. J. Merfield, Astronomical Assistant, was granted three months' leave of absence, and at the expiration of his leave he resigned his position in the public service.

Owing to Mr. Lenehan's death and the resignation of Mr. Merfield, the staff has been considerably undermanned; but, thanks to the able assistance rendered by Mr. P. P. Olden, who acted as Transit Observer during the whole of the year, satisfactory progress has been made with the astronomical work.

During 1908 a Sidereal Clock was purchased from Sir Howard Grubb, Dublin, and an order was placed with the same gentleman for a 15-inch Refracting Telescope, but the completion of the latter is delayed, pending the appointment of a new Government Astronomer.

The Officer in charge tenders his very best thanks to the whole of the staff for the loyal way in which they have supported him, and enabled him to carry out his duties.

Lovedale Observatory (Dr. A. W. Roberts's).

During the year, 1950 observations of variable stars have been made at Lovedale, for the most part observations of long-period variables. The method of observation used is a modification of that of Argelander.

Besides this work a revision of the position and brightness of the comparison stars used in the determinations of magnitude was carried out.

The reduction of all the observations of variable stars made since 1891 is now practically completed.

Mr. Tebbutt's Observatory, Windsor, New South Wales.

As systematic observations have been abandoned at this observatory, there is very little to record for the year 1908. A few observations were made with the 8-inch equatorial of occultations of stars by the Moon and of phenomena of Jupiter's satellites during the second quarter of the year. The usual meteorological observations were also carried on through the year.

Notes on some Points connected with the Progress of Astronomy during the Past Year.

Minor Planets.

The following 117 planets have been discovered or first announced during 1908. The year of discovery is 1908 unless otherwise noted.

Letter and Number.	Date.	Discoverer.	Letter and Number.	Date.	Discoverer.	Letter and Number.	Date.	Discoverer.
BM 654	Jan. 4	K	CL[a] ...	Feb. 24	M_1	DM ...	July 23	K
BN ...	3	W	CM ...	28	M_1	DN ...	23	K
BO ...	3	K	CN ...	Mar. 3	M_1	DO ...	27	K
BP ...	5	S	CO ...	3	M_1	DP ...	Aug. 20	K
BQ ..	5	W	CP ...	3	M_1	DQ ...	20	K
BR ...	12	K	CQ ...	22	W	DR ...	20	K
BS 655	12	K	CR ...	23	W	DS ...	22	K
BT ...	12	K	CS 659	23	W	DT ...	24	M_2
BU 656	22	K	CT ...	24	W	DU ...	Aug. 30	M_1
BV 657	24	K	CU ...	25	W	DO[a] ...	July 30	M_1
BW 658	24	K	CV ...	Feb. 8	H	DT[a] ...	Aug. 28	M_1
BY ...	24	K	CW ...	Mar. 30	M_1	DV ...	Sept. 21	P
BZ ...	8	M_1	CX ...	Apr. 4	M_1	DW ...	21	P
CA ...	8	M_1	CY ...	4	M_1	DX ...	21	K
CB ...	8	M_1	CZ ...	Apr. 6	M_1	DY ...	21	K
CC ...	8	M_1	DA ...	20	M_1	DZ ...	21	K
OV[a] '04	Sept. 12	B	DB ...	24	M_1	EA ...	21	K
CD ...	Jan. 30	M_1	DC ...	26	M_1	EB ...	21	K
CE ...	30	M_1	DD ...	26	M_1	EC ...	30	K
CE[a] ...	30	M_1	DE ...	May 29	K	ED ...	30	K
CF ...	Feb. 4	M_1	DF ...	June 6	M_1	EE ..	Oct. 1	L
CG ...	4	M_1	DG ...	24	K	EF ...	2	K
CH ...	4	M_1	DH ...	24	K	EG ...	6	K
CK ...	Mar. 3	W	DJ ...	25	K	EH ...	6	K
CL ...	Feb. 22	M_1	DK ...	July 22	L	EJ ...	Sept. 30	M_1

Letter and Number.	Date.	Discoverer.	Letter and Number.	Date.	Discoverer.	Letter and Number.	Date.	Discoverer.
EK ...	Oct. 4	M_1	EY ...	Nov. 29	K	ZW^c '07	Sept. 6	M_1
EL ...	27	K	EZ ...	Dec. 17	D	ZW^d '07	Sept. 6	M_1
EM ...	27	K	FA ...	16	L	AF^a '07	Sept. 12	M_1
EN ...	27	K	FB ...	16	K	AN^a '07	Oct. 8	M_1
EO ...	27	K	FC ...	16	K	AN^b '07	Oct. 10	M_1
EP ...	28	L	FD ...	16	K	AN^c '07	Oct. 10	M_1
EQ ...	28	K	FE ...	16	K	AN^d '07	Oct. 10	M_1
ER ...	Nov. 1	K	FF ...	16	K	AN^e '07	Oct. 30	M_1
ES ...	1	K	FG ...	16	K	AN^f '07	Oct. 30	M_1
ET ...	27	K	FH ...	31	W	AN^g '07	Oct. 30	M_1
EU ...	27	K	FJ ...	31	W	AN^h '07	Oct. 30	M_1
EV ...	28	K	FK ...	31	K	AN^j '07	Oct. 30	M_1
EW ...	28	W	ZW^a '07	Sept. 6	M_1	AN^k '07	Oct. 30	M_1
EX ...	28	K	ZW^b '07	Sept. 6	M_1	BJ^a '07	Dec. 8	M_1

The initials stand for: B = Prof. Barnard, Yerkes Observatory; D = Mr Davidson, Greenwich; H = S. Hirayama, Tokio; K = Herr Kopff, Heidelberg; L = Herr Lorenz, Heidelberg; M_1 = Dr. Metcalf, Taunton, Mass.; M_2 = Mr Melotte, Greenwich; P = Dr. Palisa, Vienna; W = Prof. Wolf, Heidelberg.

The following planets, not numbered at the date of the last report, have since received permanent numbers: XP 636, YE 637, ZQ 638, ZT 639, ZW 640, ZX 641, ZY 642, ZZ 643, AA 644, AB 645 (subsequently this planet was found to be identical with 398 Admete), AC 646, AD 647, AE 648, AF 649, AM 650, AN 651, AU 652, BK 653; 652 has been named Jubilatrix, 654 Zelinda.

YD is identical with 465 Alekto, 653 with 1893 D, AH with 357 Ninina, BX with 615, BL with 198 Ampella, CJ is the eighth satellite of Jupiter, DL is identical with 421 Zahringia; YH is *not* identical with 236 Honoria, as was stated last year. EA was independently found by M_1 on September 20, and is probably identical with 603; EE may be 595. BN, EW, EZ, FH, FJ were discovered in the course of the photographic search for Halley's Comet: all except EZ were very faint objects. OV^a was observed while searching for Phœbe.

Dr. M. Ebell gives in *Ast. Nach.* 4285 a list of planets photographed at Arequipa between 1898 and 1901; in the list 17 appear as known planets and 47 as unknown ones, but one of the latter was subsequently found to be identical with 643 discovered in 1907.

The interesting planets 475 Ocllo and 624 Hector were reobserved last year, and another planet, 659, has been found belong-

ing to the Jupiter group, its heliocentric longitude being 55° greater than his. The following elements are by Dr. Ebell:—

Epoch 1908 March 23·5, Berlin M.T.

$M = 240° 38' 5''$
$\omega = 327° 31' 28''$
$\Omega = 349° 57' 42''$ } 1908·0.
$i = 4° 31' 15''$
$\phi = 6° 23' 59''$
$\mu = 300''·785$
$\log a = 0·714500$

Mr. F. J. Linders, of the Lund Observatory, has made some researches on the motion of planets which nearly conform to the equilateral configuration with the Sun and Jupiter.* He finds that the instantaneous mean motion of such planets may vary from 291″·6 to 306″·6, and that the departure from the equilateral point may amount to 17°·3 in either direction. There can now be no reasonable doubt that the 4 planets, 588 Achilles, 617 Patroclus, 624 Hector, and 659, do conform to this type of motion, and oscillate about the Lagrange equilateral configuration.

Ast. Nach. 4249 contains an article by Herr P. Guthnick on the variation in brightness of Eros in 1907. The light-changes seem to have been unexpectedly small as compared with those in 1901. The suggestion that the variation depends on the phase-angle is confirmed.

We learn from *Publications of the Astronomical Society of the Pacific*, vol. xx., No. 119, that the work being done at the Berkeley Astronomical Department, University of California, on the minor planets discovered and endowed by Watson, is on the point of completion.

Tables for the following planets are nearly or quite ready: 79, 93, 94, 100, 101, 103, 104, 105, 106, 115, 119, 121, 128, 133, 139, 150, 161, 168, 174, 175, 179. Of these, the 3 planets 106, 168, 175 have approximately half the period of Jupiter; the tables of these follow Bohlin's method.

One Watson planet, 132 Aethra, is lost: it was at first thought that 654 Zelinda was identical with it, but this has not been confirmed.

In addition to 132 Aethra, it may be of interest to give the list of planets (from Nos. 1 to 500) that have not been seen since the year of their discovery, and must be regarded as lost: 99, 155, 193, 220, 285, 290, 293, 309, 310, 315, 316, 323, 330, 353, 368, 392, 396, 400, 413, 414, 428, 430, 448, 452, 457, 459, 461, 463, 464, 467, 473, 474, 486, 489, 493, 495, 496, 497, 499.

A. C. D. C.

Satellites.

At the end of February 1908 Mr. Melotte, while making a scrutiny of the plates of the region round Jupiter taken at the Royal Observatory, Greenwich, discovered an object of the 17th magnitude, which was moving at nearly the same rate as Jupiter.

* *Arkiv för Matematik, Astronomi och Fysik*, utgifvet af K. Svenska Vetenskapsakademien i Stockholm, Band 4, No. 20.

It was found on examining earlier plates that it could be traced back to January 27; before that date it was too far from the centre of the plate to be recorded. It was for some time doubtful whether it was a satellite or a minor planet that made a near approach to Jupiter; before the end of the apparition it was rendered tolerably certain that it was a very distant satellite with retrograde motion, and this has now been confirmed by the re-observation of the satellite in January 1909.

The coordinates given in *M.N.*, lxviii. 8, p. 581, are equivalent to the osculating ellipse given below.

Another ellipse was computed by Messrs. Crawford and Meyer, which is given for comparison:—

Epoch of Osculation. Perijove Passage.	*M.N.*, lxviii. 8, p. 581 1908 March 16 1908 Sept. 29·5		Crawford and Meyer 1908 March 8d 20h 1908 Aug. 25·72	
ω	105°·22	ecliptic of 1908·0	96°·00	ecliptic of 1908·0
Ω	277·46		275·18	
i	148·86		152·03	
e	0·333		0·4395	
period	830 days		931 days	
a	0·1702		0·1837	

The satellite was re-observed at Greenwich 1909 January 16; and as the place agreed more closely with that deduced from the first elements, these are probably nearer the truth than the others. In any case, there is now no doubt that the object is a retrograde satellite, with a highly eccentric orbit.

Bulletin Astronomique for October 1908 has an article by M. Gustaf Kobb on the stability of the orbits of the outer satellites of Jupiter. Satellites VI, VII are stable, but the earlier circular orbit for VIII given in *M.N.*, lxviii. 6, in which $a = 0{\cdot}213$, is shown not to satisfy the test that he uses. He has not yet applied his formulæ to the more accurate elliptical orbits given above, but it is evident that the satellite approaches somewhat nearly to the zone where the ordinary test of stability ceases to apply, which will add interest to the investigation of its motion.

Many observations of satellites VI and VII and of Phœbe have been made; the American Ephemeris now contains ephemerides of VI and Phœbe, and we understand that a second edition will contain one of VII. A. C. D. C.

The Comets of 1908.

The observations of several comets discovered in 1907 have been continued into the year, but the number of fresh discoveries is unusually small.

Comet *a* 1908, the object photographed by Professor Max Wolf on December 25, 1907, and mentioned in the last Annual Report as an observation of Encke's Comet, has probably no connection

with that body. The January observations displayed such deviations from the computed path, and such discrepancies among themselves, that Professor Backlund doubted the identity of the two objects, but thought it desirable to re-compute the perturbations during the last period, though, from the fact that the process pursued in the calculations had been precisely the same as on former occasions, it was not likely that any accidental error would be detected. Moreover, the perturbations had been checked by two independent methods. The commensurability of the mean motions of Jupiter and the comet ensures that the perturbations will be approximately repeated after intervals of about fifty-nine years. Consequently the perturbations of the 1845–8 period is an efficient check on the the accuracy of the work. In seventy-six years, the configurations of the Earth and comet also return with such exactness that Encke's ephemeris of 1832 provides a very complete control over that of 1908. The only result of the examination was to confirm the substantial accuracy of the ephemeris, to which greater precision was given by introducing terms of the second order depending upon the action of Jupiter. No computational explanation being forthcoming, Dr. Backlund suggested that while the object observed at Heidelberg could not be regarded as Encke's Comet, it was not impossible but that the comet had divided, and that, by the process of division, one of the parts had been turned into an orbit sensibly different from the original. Meanwhile, Dr. Ebell had computed a parabola direct from Dr. Wolf's measures, employing those made on January 2, 13, and 19. He found an orbit which represented the middle place with great accuracy, but had no similarity with that of Encke. The distinguishing feature of this orbit was the great perihelion distance, viz. 3·8 R. Dr. Weiss pointed out that the observed deviations from the path of Encke could not be explained by the motion of a single object, and suggested that the observations of December 25 and January 2 belonged to one object and the remainder to another, though it was not impossible that both might have originally formed parts of Encke's Comet. He selected the dates January 13, 15, and 19 as suitable to furnish a parabolic orbit, but in this instance the determination of (M) the ratio of the curtate distances at the first and third observations proved insecure, a very small variation in this quantity giving rise to very different orbits. It was possible to represent the measures in a satisfactory manner with elements in which the time of perihelion passage differed many months, and the values of perihelion distance ranged from unity to four times that amount. A value of (M) derived from the ephemeris of Encke's Comet was not more satisfactory, and an ellipse with a semi-axis major assumed at 2·216 led to no more conclusive result. The important fact that followed this investigation was the decision that Professor Wolf's object would not pass into the southern hemisphere as Encke's Comet did, and that it would be possible to observe the same object in May in the northern hemisphere, since the brilliancy would not greatly diminish, and the various orbits agreed in indicating the

position within tolerably close limits. So far as is known, however, the object or objects have not been again seen; and the curious fact remains, that after accurate observation for more than three weeks we are unable to determine the approximate path in which the object was moving. In some respects the history of this object recalls that of the famous Comet of D'Angos, each presenting a difficulty that has never been solved.

Comet *b* 1908 is the real Comet Encke, which was found at the Cape of Good Hope by Mr. Woodgate on May 27. Observation showed that the error of the ephemeris was +5 m. 22 sec. in R.A. and −33′ in declination, deviations from the computed path as large as in the case of Professor Wolf's object, but at the end of May the comet was much closer to the Earth than in January. The comet was followed by means of photographs till the 5th. of June, but remained a very faint object.

Comet *c* 1908 was discovered by Mr. Morehouse of the Yerkes Observatory on September 1, and reported at the time as a conspicuous object with a long tail. This description seemed to indicate the approach of a brilliant comet, but for some time the increase in lustre was very slow. Subsequent observations revealed very great changes in the structure of the tail about the dates September 16, October 1 and 15, so that it is not impossible that at the time of its discovery the comet was undergoing one of those periodic fluctuations which temporarily increased the brilliancy. Though the comet became visible to the naked eye, its general appearance was disappointing; but, owing to the nature of the variations, its history is one of the most interesting in modern times. These changes have been unusually rapid, and even in its quieter moments photographs at very frequent intervals have been necessary to explain the changes in structure. At all the principal observatories a series of photographs has been obtained, and these have been amply supplemented by much admirable amateur work, to which it is impossible in this place to do adequate justice. The wealth of material collected has been so great that it has not yet been fully discussed. The one fact that stands out clearly established is, that the process of formation of the tail is intermittent rather than continuous. In no comet hitherto observed has this feature been so distinctly marked, or the motion of the matter forming the tail so clearly traced. The behaviour of the nucleus, the sequence of changes through which the comet passes as parabolic envelopes appear on the side towards the Sun, the sweeping round to produce a tail, fan-shaped and streaming, subsequently breaking up into flocculent masses, have never been demonstrated before with the same clearness, and the actual measurement of the motion of the material forming the tail has been possible under more favourable conditions than ever before. As a result, it has been recognised, both at Greenwich and Heidelberg, that the velocity of motion increases the further the matter is away from the nucleus. Professor Barnard calls attention to the sudden brightening up of parts of the tail where apparently no material

previously existed, and where there was no visible supply reaching it from the comet. This phenomenon is compared with what is frequently seen in auroral streamers. Others have questioned how far the motion is real or apparent. Some of Professor Max Wolf's photographs suggest that the presence of knots or condensations of material in the tail is due to the superposition of detached bands or rays crossing one another, giving rise to regions of increased brilliancy at the point of intersection, and shifting as these rays alter their relative positions.

The spectrum, which has been observed at many observatories, presents some unusual features. The continuous spectrum usually seen in bright comets has been exceedingly faint, and some observers report it absent. Some of the ordinary hydrocarbon bands have been seen by Frost and Parkhurst, whilst Deslandres and Bernard find no trace of them. The bands of cyanogen are incomplete, the second being wanting. At the Lick Observatory certain lines have been observed of which the origin is doubtful. They have not been identified with the lines of any element or compound hitherto examined in the laboratory. The presence of these unexpected lines in the blue and violet, and the faintness of the continuous spectrum, suggest an explanation of the great chemical activity and feeble visual intensity which have been marked features in this comet.

Comet *d* 1908 is a return of the Comet Tempel$_3$-Swift, which has not been seen since 1891. This faint comet was found at Nice by M. Javelle on September 29, employing an ephemeris furnished by M. E. Maubant. The observations show the necessity of an alteration in the computed time of perihelion passage of 3·646 days, or a diminution of the mean motion by $0''\cdot38$. M. Maubant recalls the fact that M. Bossert, who computed the perturbations, small in amount, between 1880 and 1891, also found it necessary to reduce the motion by the same quantity in the same direction, and he suggests the possibility of the existence of a negative acceleration, of which some evidences have been detected in the motion of the periodical Comets of Tempel and of Brorsen.

The orbits of the following comets have been definitely determined during the year :—

Comet.	Character of Orbit.	Calculator.	Place of Reference.
1813 I.	Parabolic	H. A. Peck	*Ast. Journal*, No. 601
1826 V.	,,	Hnatek	*Ast. Nach.* No. 4269
1886 V.	Ellipse	Bucht	*Ast. Nach.* No. 4264 *Schwed. Akad. der W. Stockholm.*

The past history of Halley's Comet, to which reference was made in the last Annual Report, has been further investigated by Messrs. Cowell and Crommelin, who may be heartily congratulated upon the success of their results. The path has been satisfactorily traced back to the beginning of the Christian era, and with great proba-

bility to some earlier returns. With regard to the coming apparition, Professor Holetschek, Dr. Smart, and others have published ephemerides to facilitate its recovery. The magnitudes assigned by the first-named astronomer show that, notwithstanding improved modes of search, there has hitherto been little chance of success.

Solar Activity in 1908.

Sun-spots.—Although several very fine spots have been seen on the Sun's surface during the year, especially two at the end of August and the middle of September, yet the general character, size, and positions of the spots denoted a decline in the solar activity. The first quarter of the year was marked by a quiet period, succeeding the great outbursts witnessed in November and December 1907. The groups observed were of no great area, and bright faculæ were relatively scarce, and mostly seen on the E. limb. The spot groups, too, were generally of the character denoted by Types I. and IV. which mark the quiet and dying phases of spot activity, with a very noticeable dearth of spots represented by the active Types II. and III. And in general this was the character of the spot groups observed during the year, with the exception of some outbursts to be noted directly. The long processions of groups prevalent in the years 1906, 1907 were replaced by a series of many round regular quiet spots, several of them affording excellent material for testing the Wilsonian hypothesis of sun-spot level.

The first active period of the year set in with the beginning of April, announced, as is so often the case, by the appearance of a bright compact patch of faculæ on the E. limb, and lasted until the middle of the month, with somewhat of a revival when the groups returned again at the end of the month. Even so, the general type of the spots noted above was preserved. But the faculæ were brighter and more abundant. A quiet May was followed by a revival of activity at the beginning of June, which was of no long duration, the quiet spell that succeeded lasting until the end of July. But now began the most active period of the year, covering the months of August and September, four of the groups observed being visible to the naked eye. The middle of August was marked by four fine groups, and an exceedingly fine group appeared towards its close. This, the biggest group of the year, was on the central meridian on August 31·2, and on August 30 covered a total area of about 1500 millionths of the visible disc. The next in size was group 6522 of the Greenwich series, which was on the central meridian on September 10·3 and was accompanied in its passage by a very violent magnetic storm, the greatest of the year. The region in which it appeared had been the seat of the great sun-spot group of November 1907 which had itself synchronised in its first passage across the disc with two days of great magnetic storm. However, after the fourth appearance of this same group, central on February 4·9, 1908, the region had

remained dormant until this revival of August. These greater disturbances showed the characteristics of the active Types II. and III., but, even so, they were very penumbral in appearance, being apparently not very deep spots. They died out finally about the middle of October, which was on the whole a very quiet month, October 15 being the only spotless day in the Stonyhurst records of 187 drawings during the year. November, too, was quiet, with the exception of a fairly active period from the 8th to the 14th, while December, except for the appearance of a couple of fine round spots, was even quieter.

With regard to the positions of the groups, if they are counted, great and small, independently of their size, the following is the result.

	N. hemisphere.	S. hemisphere.
Groups in latitudes above 20° . . .	2	7
,, ,, ,, between 20°–10° . .	56	74
,, ,, ,, ,, 10°–0° . .	41	53
Totals . .	99	134

It appears that the southern hemisphere was on the whole the more active, and that in both hemispheres about 40 per cent. of all groups were in latitudes lower than 10°, amongst them being the biggest groups of the year. This tendency of the groups to close in towards the equator is a further indication of the decline of activity. At the same time the long spell of sun-spot outbursts which has been witnessed since 1905 is to be noted, and is probably due, as Professor Schuster points out (*Nature*, November 5, 1908), to the overlapping of the well-marked period of 4·79 years upon the eleven-year period. The regions of special activity, that is in which there was a general clustering of the groups observed, were for both hemispheres bounded by longitudes 150°–185°, latitudes north and south 5°–18°, and in addition, for the north hemisphere that comprised within longitudes 250°–290°, latitudes 5°–15°, and for the south hemisphere the region longitudes 200°–230°, latitudes 10°–22°. A. L. C.

Prominences.—The daily frequency of prominences during 1908, as deduced from spectroheliograms taken on 38 days on various dates extending from April to November, is given below.

The photographs used were taken with the "K" line (calcium) of the solar spectrum by means of the spectroheliograph of the Solar Physics Observatory, South Kensington. No discrimination as to size has been made, except that the lower limit for height of prominences accepted was from 20″ to 30″. The result shows a considerable decrease in the total activity as compared with the similarly obtained records for previous years.

Judging from the information thus available, the prominence frequency is rapidly on the downgrade, while the preponderance of activity in the southern hemisphere is more marked than in 1907. On the plates examined, there was little evidence of action at either

pole, the maximum number of disturbances occurring in spot latitudes and immediately higher. Equatorial prominences were not infrequent.

The data for the last four years, as deduced at South Kensington, are as follows :—

	1905.	1906.	1907.	1908.
North hemisphere . . .	3·4	3·9	3·5	2·5
South hemisphere . . .	3·0	2·6	3·9	3·1
Total daily frequency	6·4	6·5	7·4	5·6

The fewness of the number of days on which it has been possible to obtain good prominence records makes the above figures merely suggestive, and not final.

The poor observing weather of 1908, combined with the unfavourable situation at South Kensington, has very effectively militated against a fuller record.

In previous reports I have been able to include observations made during the first six months of the year by A. Riccò, but up to the present these are not available. W. J. S. L.

Solar Research.

Sun-spot Spectra.—The first portion of a "preliminary catalogue of lines affected in sun-spots," based upon photographs taken at Mount Wilson, and covering the region λ4000 to λ4500, has been published by Adams (*Ap. J.*, xxvii. 45). The behaviour of nearly nine hundred lines is indicated.

Following Fowler's identification of the banded spectrum of magnesium hydride in spots, Olmsted, of the Mount Wilson laboratory, has found that an arc burning between poles of metallic calcium in an atmosphere of hydrogen gives a number of bands, the two most prominent of which account for the well-known spot bands in the red near 6382 and 6389. From experimental evidence, it is considered probable that the bands in question are produced by some compound of calcium and hydrogen (*Ap. J.*, xxvii. 66).

Father Cortie has drawn attention to the apparent strengthening in sun-spots of many lines which are attributed to water vapour, which has led him to suggest the possible existence of water vapour, in the form of superheated steam, over sun-spots (*Ap. J.*, xxviii. 379).

The Mount Wilson equipment for the investigation of sun-spot spectra has been extended by the erection of a vertical telescope of 60 feet focal length combined with a spectrograph of 30 feet focal length. The cœlostat and objective are placed at the summit of a skeleton steel tower about 60 feet high, while the spectrograph, which is of the autocollimating type, occupies a circular well $8\frac{1}{2}$ feet in diameter and 30 feet deep. The reduced atmospheric

disturbance of the primary image, and the constancy of temperature of the spectrograph, have contributed to very successful photographs of the spot spectrum (*Ap. J.*, xxvii. 204). Professor Hale is arranging for the erection of a similar instrument with a spectrograph of 75 feet focal length, to work in conjunction with an object-glass of 150 feet focal length (*Ap. J.*, xxviii. 343).

In consequence of the demand for increased electrical power created by the sun-spot work on Mount Wilson, an additional laboratory has been equipped in Pasadena. Profiting by experience with the new Tower Telescope, Professor Hale has here erected a 30-feet autocollimating spectrograph in a well of corresponding depth below the floor of the laboratory, and has conveniently arranged the electric furnace and other light sources about the slit as centre (*Ap. J.*, xxviii. 244).

The first results from the new laboratory refer to the electric-furnace spectra of titanium and vanadium, which have been investigated by Dr. King. A furnace of the "tube resistance" type was employed, and temperatures ranging up to 3000° C. were attained. Under these conditions, 85 per cent. of the arc lines were present in the case of titanium, and 73 per cent. in the case of vanadium; but the relative intensities were different from those of the arc spectrum, enhanced (spark) lines being notably weakened. Dr. King concludes that since electrical action other than ionisation at a heated surface was entirely excluded, and possible chemical action was reduced to a minimum, "there is nothing to indicate that temperature was not the sole and sufficient agent in producing these spectra" (*Ap. J.*, xxviii. 300). Professor Hale is of opinion that these investigations leave little doubt as to the correctness of the view that the changed intensities of the metallic lines in spots are due to a reduction of temperature in the spot vapours (*Ap. J.*, xxviii. 319).

The spectrum of scandium has been investigated by Fowler. It is found that the enhanced lines are much more prominent in the solar spectrum than the other lines, and that, while the former are weakened in spot spectra, the latter are very considerably strengthened (*Phil. Trans.*, vol. ccix*a*. p. 47).

In a paper read at the meeting of the British Association, Professor Whittaker criticises the evidence which has been brought forward in support of the view that the sun-spot spectrum directly indicates a relatively low temperature. Attention is drawn to the fact that the mere existence of bands due to compounds is inconclusive, since compounds may be formed by increase of pressure as well as by reduction of temperature. It is also suggested that the variations in the intensities of the metallic lines might be produced by high pressure in the spots (*Observatory*, xxxi. 372). On the other hand, Mr. Evershed states that a series of measures made by him of certain iron lines which are subject to large pressure shifts prove that in the spots examined the pressure could not have differed by more than a quarter of an atmosphere from that over the adjacent photosphere (*Observatory*, xxxi. 463).

An observation which bears upon the significance of enhanced (spark) lines in sun-spots and other celestial light sources has been recorded by Hemsalech and De Watteville. It is stated that some of the enhanced lines of iron in the ultra-violet are among the lines given by the inner cone of a Bunsen flame fed with air carrying fine particles generated by an enclosed arc or spark. These lines are not seen in the presumably hotter oxyhydrogen flame (*Comptes Rendus*, June 29).

The supposed "reversals" of lines in sun-spot spectra first described by Young, and afterwards by Mitchell, have received a new interpretation. These lines have been successfully registered by the 30-feet spectrograph at Mount Wilson, and the possible existence of a magnetic field in spots having been suggested by the discovery of vortices about spots in spectro-heliographic work on the Hα line, the polarisation phenomena were carefully investigated. In accordance with experiments on the Zeeman effect, it was found that in the case of spots near the centre of the disc, one or other component of the really double lines could be extinguished by suitable adjustment of a Fresnel rhomb and Nicol prism in front of the slit. The two components are thus circularly polarised in opposite directions, and it is deduced that the rapidly moving particles which produce the field are negatively charged.

When the rhomb and Nicol are adjusted to extinguish one of the components in the case of a spot associated with a vortex moving in a particular direction, the other component is extinguished if another spot in which the vortex motion is oppositely directed be brought on the slit, the apparatus being otherwise as at first. In the case of a spot near the limb, the field is nearly at right angles to the line of sight, and the doublets observed away from the limb are replaced by triplets in accordance with theory and experiment. From the measured separation of the doublets, Professor Hale estimates the strength of the magnetic field as about 1000 Gauss units; and as there is evidence that it rapidly diminishes in passing outwards, he considers it very improbable that terrestrial magnetic disturbances are caused by the direct effect of the magnetic field in spots (*Ap. J.*, xxviii. 315). Dr. Schuster has also concluded that "the magnetic disturbances hitherto associated with the state of the sun's surface cannot be accounted for by the direct magnetic action of Professor Hale's solar vortices" (*Nature*, lxxix. 280).

Helium Absorption near Spots.—Photographs showing a dark line, apparently corresponding to D_3, in the neighbourhood of sun-spots, have been obtained by Mr. Nagaraja at Kodaikánal. These have been discussed by Father Cortie, Mr. Buss, Captain Daunt, and Mr. Evershed, and much valuable information has been given as to the conditions of visibility of the line (*Observatory*, xxxi. 51, 94, 133, 250, 353). Details of observations of this line during 1907 have been published by Captain Daunt (*M.N.*, lxviii. 620).

The Sun's Rotation.—The results of a further investigation of

the position of the sun's axis of rotation, as deduced from the records of spots for the period 1874–85, have been given by Professor Turner. It is suggested that the axis may possibly be describing a cone in space in a period which is nearly a year (*Papers of the I.U.S.R. Computing Bureau*, No. II.; *M.N.*, lxvii. 609.)

An important spectroscopic investigation of the sun's rotation as determined from displacements of the hydrogen lines has been made by Adams, from photographs taken at Mount Wilson. It is concluded, first, that the rotational velocity of the hydrogen gas is decidedly higher than that of the general reversing layer, amounting at the equator to 1° in the daily angular motion, and that the effective level of the absorbing gas lies very high in the Sun's atmosphere. The second conclusion drawn from the observations is that at the level of the hydrogen gas there is no equatorial acceleration similar to that indicated by low-level vapours and by the movements of sun-spots (*Ap. J.*, xxvii. 213).

A companion investigation has been made by Professor Hale on the rotation of the sun as determined from the motions of the hydrogen flocculi. The results agree with those of Adams in showing that the hydrogen in the sun does not show the equatorial acceleration observed in the case of sun-spots, faculæ, calcium flocculi, and reversing layer. As in the case of dark calcium flocculi to which attention was drawn by Mr Michie Smith, Professor Hale is of opinion that some of the dark hydrogen flocculi are also prominences photographed in projection on the Sun's disc (*Ap. J.*, xxvii. 219).

Mr. Fox, of the Yerkes Observatory, finds that only a small percentage of the prominences shown on the Sun's limb can be clearly followed on the disc as dark calcium flocculi. A preliminary attempt to determine the sun's rotation from these appearances indicates that the motion agrees closely with the motion of the hydrogen flocculi (*Ap. J.*, xxviii. 117).

The Spectroheliograph.—In addition to the work already mentioned, Professor Hale has obtained photographs on the Hα line which give unmistakable evidence of the existence of vortices about sun-spots. In one series of photographs a large hydrogen flocculus is depicted in course of being drawn into a spot, and Professor Hale is led to conclude that "sun-spots are centres of attraction, drawing toward them the hydrogen of the solar atmosphere." Reference has already been made to the magnetic field in spots to which the vortices are believed to give rise (*Ap. J.*, xxviii. 100).

Mr. Fox has given careful attention to the specially bright points in the calcium flocculi which occur in the neighbourhood of spots, and has concluded that they are the bases of eruptive prominences. Their spectra sometimes show many metallic lines and other appearances similar to those observed in prominences, and when traced to the limb prominences are seen to overhang the

(eruptive) flocculi. It should thus be possible to determine the distribution of eruptive prominences on the sun's disc (*Ap. J.*, xxviii. 258).

Spectroheliograms in the calcium line K_3 (the central dark reversal) have been obtained by Deslandres. Some of the long dark filaments shown on the photographs persist in the same positions for several rotations, and it is suggested that spots and filaments are manifestations of different parts of the same cyclonic motion (*Comptes Rendus*, November 30, 1016).

The development of a prominence which appeared on February 18, as illustrated by a series of twenty photographs taken at Kodaikánal, has been described by Evershed. The most striking feature was the accelerating velocity with which the entire mass left the sun (*Ap. J.*, xxviii. 79).

Structure of the Photosphere.—A study of the granulation of the photospheric surface has been made at Zô-sè by Chevalier. The granules found in a given photograph were quite unrecognisable in one taken ten minutes later, but on plates taken at intervals of a minute or half a minute they were substantially the same, though showing changes of shape, brightness, and relative positions. The displacements observed in comparing successive plates range from zero to thirty or more kilometres per second, and are widely different in direction. It is suggested that these displacements do not represent horizontal motion, but may correspond to undulatory movements more or less similar to those seen in a choppy sea (*Ap. J.*, xxvii. 12).

Further investigations of the movements of the solar granules made by the late Alexis Hansky have also been published. It is concluded that sun-spots have an oscillatory movement relative to the whole surface, the maximum velocity being 400 metres per second, and that the photospheric granules have non-periodic movements of short duration, with velocities of about 4 kilometres per second (*Mitt. Hauptsternwarte zu Pulkowo*, iii., No. 25; *Observatory* xxxi. 469).

The Solar Constant and Temperature of the Sun.—From measures of the sun's radiation made with the Ångström pyrheliometer, Dr. Scheiner deduces the value 2·22–2·29 calories for the solar constant. "The effective temperature" of the sun resulting from the observations is 6196° to 6252°, and it is estimated that the average real temperature of the photosphere is 7065° (*Pub. Ast. Obs. zu Potsdam*, No. 55; abstract in *M.N.*, lxviii. 662).

From a discussion of Langley's observations, Dr Goldhammer has estimated the actual temperature of the sun as 10,000° (*Ann. der Physik.*, xxv. 905), while Dr. O. Lummer considers it to be in the neighbourhood of 7000° (*Bull. Phil. Soc. Washington*, xv. 75).

An extended account of work on the solar constant has been given by Abbot and Fowle in vol. ii. of the *Annals of the Astrophysical Observatory of the Smithsonian Institution* (Washington,

1908). Details and discussion of comparable observations extending over several years are given ; they are believed to indicate that the sun's radiation changes in intensity from time to time, and that these alterations are sufficient to appreciably affect the temperature of the earth.

Miscellaneous.—Professor R. W. Wood has pointed out that the presence of radially polarised light in the solar corona does not necessarily indicate the scattering of sunlight by small particles. He has found that the fluorescent light emitted by comparatively cool metallic vapours is strongly polarised, even when the exciting light is unpolarised. With mixed vapours the integrated complex fluorescence spectra would appear practically continuous, as is the case with the corona. Professor Wood considers it possible that the green line and other lines observed in the coronal spectrum may be the fluorescent lines of well-known substances (*Ap. J.*, xxviii. 75).

Dr. Schuster points out that the renewed sun-spot activity in August was possibly connected with the 4·79-year period, which he has previously shown to have persisted since sun-spots were first systematically observed (*Nature*, lxxix. 7).

An account of some anomalous forms of the K line of calcium in prominences, with numerous illustrations, has been published by Belopolsky (*Mitt. Hauptsternwarte zu Pulkowo*, ii., No. 24).

From a discussion of photographs of the corona of 1905, the late Alexis Hansky considered it probable that the forms and directions of the streamers depended upon the prominences over which they appeared. Some streamers seemed to emanate from points near to, but not coincident with, spots (*Mitt. Hauptsternwarte zu Pulkowo*, ii., No. 19).

The second volume of the *Transactions* of the International Union for Solar Research has been issued (University Press, Manchester). A full account of the proceedings at the Meudon Conference of 1907 is given, together with reports of committees and a few original papers. Definitive values of the new wave-lengths of standard iron lines are given by Fabry and Buisson (also in *Ap. J.*, xxviii. 169). A. F.

Double Stars.

The abbreviations used are—

M.N. : *Monthly Notices.*
A.N. : *Astronomische Nachrichten.*
L.O.B. : *Lick Observatory Bulletin.*
B.A.A. : *Journal of the British Astronomical Association.*

The number of measures published during the year is about the average:—E. D. Roe (6½-inch Clark), Syracuse, N.Y., gives a first contribution in *A.N.* 4259 of 47 pairs, ranging from 1″·0 to 53″·0 separation.

Professor Burnham (40-inch Clark), Yerkes, in *A.N.* 4261, has

measures of about 200 pairs, in continuation of those in *A.N.* 4209. These are mostly wide neglected pairs.

A fine series of measures of 150 pairs, mostly Struve, in *A.N.* 4279, is by H. E. Lau (10-inch), Copenhagen; and Dr. Küstner has some measures in No. 10 of the Bonn Observatory publications, *Katalog von* 10665 *sternen.*

The annual results of the measures made at the Royal Observatory, Greenwich, are in *M.N.*, May. There are about 380 pairs under 4″ separation, made with the 28-inch Grubb refractor. Measures of wider pairs are not given.

Measures of southern pairs are contributed by Mr. Tebbutt in *M.N.*, March (8-inch, 13 pairs); by Mr. Hirst in *B.A.A.*, xviii., No. 4 ($4\frac{1}{4}$-inch, 14 pairs); and by the late Mr. J. Scott (5-inch), Shanghai. These measures of 110 pairs, ranging from 1″ to 20″ separation, form Mr. Scott's last work. He died on his journey home, 1908 January.

The most important series of measures is in the "Catalogue and Re-measurement of 648 Double Stars discovered by Professor G. W. Hough." This forms part iii., vol. iii., of the Publications of the University of Pennsylvania, and is the result of measures from 1901 by Dr. Doolittle, at the Flower Observatory. In addition to his own measures, Dr. Doolittle gives all published measures for each pair—a work very much needed.

Mr. Espin contributes 57 new pairs, separation 3″ to 40″, in *M.N.*, May, and Dr. Aitken has continued his systematic search for new double stars. By the addition of 200 (Nos. 1701 to 1900) he has outstripped all living double star discoverers. He hopes to complete his work in another two years.

An unusually large number of orbits have been computed during the year. The number given in brackets is the period deduced. In *A.N.* 4260, E. Schoenberg gives orbital elements for β 581 (33·6), β 612 (34·2), and 8 Sextantis (72·8).

Dr. See publishes elements for β 80 (63·5), β 513 (53·0), and β 552 (56·0) in *M.N.*, 1908 January, and for ξ Bootis (143·0), Σ 483 (135·5), Σ 3123 (103·3), Dembowski 15 (96·0), Secchi 2 (16·0), Σ 2 (166·0), β 581 (41·2), Σ 2438 (233), β 524 (36), 8 Sextantis (68·8), χ Velorum (10·0), and β 883 (16·6) in *M.N.*, June.

The orbit of β 416 (41·5) by J. Voûte is also in *M.N.* June, and Dr. Doberck has an orbit of γ Virginis (182·3) in *A.N.* 4235. The latter has a note on θ Orionis in *A.N.* 4270; and in *A.N.* 4229, in a paper "On the Accuracy of Measurement by the Principal Double Star Observers," he shows that errors of measurement are of a very small order (not greater that 0″·05), and he also brings out the interesting fact that the error *increases* with separation.

Dr. Aitken has an orbit, with very small residuals, in *L.O.B.* 141 of β 612 (34·4); and a note by Mr. Innes in *Observatory*, No. 398, indicates that the star Lacaille 7194 will be a short-period binary. In *M.N.* (Suppl. No.) Professor Barnard gives the

history of the system Krueger 60, and from his fine series of measures shows that the close pair is a short-period binary, and that the parallax is 0″·249.

In *M.N.*, June, Dr. See, in a paper on the "Comparative Eccentricities of Visual and Spectroscopic Binaries," shows that the average eccentricity among visual binaries is more than twice that among spectroscopic.

Dr. Abetti, in *A.N.* 4270, gives the parallax of 61^1 Cygni as 0″·24, and of 61^2 Cygni as 0″·22; and in *A.N.* 4250 Professor G. Comstock is able to reconcile, *inter se*, the measures of the small stars near 70 Ophiuchi by assuming the masses of the two components equal.

A series of articles by Mr. Lewis have appeared in several numbers of the *Observatory*, on the history of double star work, the computation of orbits, and on formulæ connected with orbital planes, masses, parallax, magnitudes, etc. The editors are issuing the collected articles in a small book.

One of the most important works of the year is *Publikationen des Astrophysikalischen Observatoriums zu Potsdam.* This volume by Dr. Lohse is divided into two parts:—

1. The measures made by Dr. Lohse with the 11-inch refractor during the years 1899 to 1907.
2. Computation of orbits.

Dr. Lohse measured 166 selected pairs, and, where possible, he has also collected previous measures and deduced orbits. Altogether he computes twenty-nine orbits:—β 524 (27·3), β 883 (17·0), β 621 (34·4), ξ Bootis (159·5), Σ 3062 (114·2), η Cassiopeiæ (345·6), Sirius (49·3), Castor (297·5), 9 Argus (23·5) Σ 3121 (35·1), OΣ 235 (69·7), γ Virginis (177·8), α Centauri (78·8), ζ Bootis (170·6), η Coronæ (40·6), μ_2 Bootis (244·4), ξ Scorpii (44·7), λ Ophiuchi, (123·2), Σ 2107 (134·6), Σ 2173 (45·7), μ_1 Herculis (44·7), 70 Ophiuchi (87·9), 99 Herculis (53·5), β 648 (50·9), OΣ 387 (90), β 151 (27·0), τ Cygni (48·5), and κ Pegasi (11·2). There is a review in *Observatory*, No. 405. T. L.

Variable Stars.

The discovery of new variable stars seems to have gone on in 1908 at about the same rate as in the preceding year, the latest provisional designation given in the *A.N.* for 1908 being No. 171. Harvard College Observatory, as before, is responsible for a large proportion of these. In *H.C.O. Circulars*, Nos. 135, 137, 139, and 140 to 143, no less than 152 new variables are announced. Of this number 148 form part of the 171 just referred to.

Dr. J. Hartmann finds that the spectrum of the celebrated Nova Persei 1901 changed to the nebular condition towards the end of 1902, while in 1906 it changed again to that of the Wolf-Rayet stars. Professor E. E. Barnard has observed that changes in

the focus for this star in the 40-inch refractor of the Yerkes Observatory coincide with Dr. Hartmann's work. At first (1901) the focus was the same as that of an ordinary star. Between 1902 August 29 and October 6 the focal length increased nearly a quarter of an inch, and was the same as for a nebula. By the end of January 1903 the focus had again become stellar (*A.N.*, 4232, 4285).

In *H.C.O. Annals*, vol. lxiv. pt. ii., is published a monograph on the variable *SS Cygni*. The normal magnitude is 11·8 for two-thirds of the time. During the remainder the star rises capriciously to various magnitudes, ranging up to 8·8, and at present there seems to be no law known which will correlate these curious outbursts of light. It may be noted here that this variable is under special scrutiny by the variable star section of the *B.A.A.*; and during 1908, 747 observations have been secured, well covering every phase of its irregular fluctuations in that year.

Mr. J. Van der Bilt has also (*Recherches Astronomiques de l'Observatoire d'Utrecht*, iii.) dealt exhaustively with a variable of similar class, the well-known *U Geminorum*. He sums up his conclusions as follows: "All attempts to detect some law in the changes of the period have failed; and it is to be feared that this will remain so until a long series of observations, as continuous as the position of *U Geminorum* in the ecliptic allows, constitute a more complete basis for further inquiry. As the material now lies before us, only useless speculations can result from it."

Much good work is being done at the Laws Observatory, University of Missouri, by photometric observations of certain variables discovered in recent years. Two forms of instrument are used: (1) A disc photometer, by means of which "the apparent intensity of a luminous source can be diminished by a definite and known amount. It consists essentially of a rotating disc, from which a number of sector-shaped areas have been cut away," and the artificial source of light is made equal in intensity to the star under observation. (2) The wedge photometer is on the principle of that of Zöllner, in which an artificial star is formed in the telescope alongside the real one. The intensity of the former is varied until the two images are equal. The so-called "wedge" is really a strip of photographic negative in which the blackening of the film increases from one end to the other.

Mr. T. H. Astbury, a member of the *B.A.A.*, has recently discovered a new variable of the Algol type, provisional designation 16, 1908 Vulpeculæ. It is B.D. + 22°, 3647. The period is 4·47 d., variation 6·7 m. to 8·0 m. The same observer has confirmed (independently) the variation of 26, 1900 Vulpeculæ = B.D. + 25°, 3803. This also is of Algol type; period probably about 5 d., variation 7·3 m. to 8·3 m.

Series vi. of the *Atlas Stellarum Variabilium* has now appeared, thus completing the original scheme of the work. It is on the same lines as the other sections, and the whole work forms a thoroughly accurate guide (by chart, and by list of comparison

stars) in the observation of over 300 variables. We must congratulate Father Hagen on the completion of this, his great task.

Vol. lviii. of the *R.A.S. Memoirs* contains the observations of thirty-one variable stars, principally of long period, made by the late N. R. Pogson in the years 1852–1880, but left unpublished by the observer. They have been edited with great care by Mr. C. L. Brook, M.A., F.R.Met.Soc., the introduction being by Prof. H. H. Turner, F.R.S. The observations are valuable as connecting the time of Argelander with the period when the study of stellar variation began to get more general; and they are also of interest as having been made by an astronomer who himself discovered at least fifteen variable stars, and established the light ratio (2·512) now generally adopted. Pogson's good work must be of great use to all who are engaged in the study of long-period stellar variations. The magnitudes of the comparison stars are carefully reduced, and the notation adopted in the record, indicating the comparison star by its magnitude, enables the resulting magnitude to be checked at a glance by the reader. A chart of the vicinity of each variable is given, and other information of much value is contained in the volume.

The following three important works connected with stellar photometry, and therefore incidentally with variable stars, may be briefly noticed here.

The *Revised Harvard Photometry* (vol. I., *Annals H.C.O.*) gives a catalogue of the brightness and spectra of 9110 stars, distributed over the whole sky, and chiefly brighter than 6·50 m. This brings together in a convenient form the previous results of the photometric work of H.C.O.; and a comparison of the mean magnitude of each star now given is made with the former determinations, as well as with the catalogues of Sir William and Sir John Herschel, the U.N. Oxon., Potsdam, and of A. S. Williams. It may be noted that the letters H.R. followed by a number represent a star in this catalogue.

Vol. liv. of the *Annals H.C.O.* is "*A Catalogue* of 36,682 *stars* fainter than the magnitude 6·50 observed with the 4-inch Meridian Photometer." This work also represents the outcome of previous observations scattered through several volumes of the *Annals*, and extends over the whole sky. Owing to the large number of stars, and the consequent necessary economy of space, the entry against each star is more condensed than in vol. I., but the B.D. number, position, magnitude, number of observations, and reference to previous vols. of the *Annals* are given.

These two volumes, then, form a complete catalogue, and, as it were, crown the labours of light-gauging carried on at H.C.O. for close on thirty years with such admirable tenacity of purpose by Professor E. C. Pickering and his staff.

The *Photometric Durchmusterung of Potsdam* is contained in vol. xvii. of the Publications of that Observatory, prepared under the direction of the late Professor Vogel. It gives the position and brightness of all the stars in the northern heavens

brighter than 7·5 m., the number being 14,199. The magnitudes were obtained by Müller and Kempf, with a Zöllner Photometer, during the years 1886 to 1905, and are very carefully determined. Comparing with the work of H.C.O., however, it is at once seen that there are considerable differences in brightness; hence, for the present, the second decimal of a star's magnitude may be regarded as more or less a figment, and it will be so until a more accurate standard of stellar light-measurement is obtained. Yet, with the three volumes just referred to, astronomers possess a most valuable record of the brightness of many thousands of stars, which will doubtless be of the greatest use for reference, comparison, etc. in various stellar researches. E. E. M.

Stellar Distribution and Drift.

Professor Lewis Boss (*Astronomical Journal*, No. 604), from the results of his determinations of proper motions of fundamental stars, has arrived at an interesting conclusion with regard to a number of stars in Taurus. He finds that thirty-nine stars, mostly brighter than the sixth magnitude, have proper motions accurately directed to a single point of the celestial sphere. The mean deviation in position angle of the proper motions is $\pm 1^{\circ}\cdot 8$. It appears that these stars form a globular cluster about 15° in diameter, having a central condensation; we may expect that many fainter stars will be found to belong to the cluster as soon as their motions have been determined with sufficient accuracy. The great angular dimensions of the cluster are due to its comparative nearness to the Earth at present; for example, it is estimated that in about sixty million years this Taurus-stream will appear as an ordinary globular cluster about 20′ in diameter, constituted of stars of magnitudes 9–12. If this system is to be taken as typical of globular clusters in general, it would indicate that their linear dimensions may be much greater than is often supposed, for in this case it is clear that the distances of the component stars from each other cannot be much less than ordinary stellar distances.

A further advance in the investigation of the systematic motions of the stars has been made by Professor Dyson (*Proc. Roy. Soc. Edin.*, vol. xxviii. part. iii.). His results were obtained from the discussion of stars having large proper motions, distributed in all parts of the sky. The two favoured directions of motion were shown in a very striking manner, and were found to prevail in every region (including the part of the sky below 30° S. declination which had not previously been examined). In general, the investigation confirms and extends previous work on this subject; the principal divergence is in the position of the apex of the slower moving stream II.; there is also an indication that the velocity of this stream is rather greater than the value found from the Groombridge stars.

Professor Schwarzschild has made a great practical advance in the development of his theory (referred to in the last report), by

providing a very simple and convenient method of discussing the systematic motions of small groups of stars (*Göttingen Nachrichten*, February 1908). This method has been applied by Beljawski (*Ast. Nach.*, No. 4291) to the determination of the vertex and apex from Porter's proper motions. This position of the vertex (*i.e.* the direction of the major axis of the velocity-ellipsoid) is $A = 266^\circ$ $D = +24^\circ$, and thus differs seriously from the position found by Schwarzschild from the Groombridge stars, $A = 273^\circ$ $D = -6^\circ$; but it must be remembered that Porter's stars are those having large proper motions only, and the method used is strictly only applicable to unselected proper motions. Eddington (*Monthly Notices*, lxviii. p. 588) has given a method of applying the two-drift theory to the discussion of small groups of stars, and has examined by it the proper motions of the stars of the Zodiacal Catalogue.

A list of the determinations up to the present of the positions of the apices of the two streams and of the *vertex* (or direction of motion of one stream relative to the other) is given below. It may be noted that every one of the six determinations was made by a different analytical method.

	Apex. Stream I.		Apex. Stream II.		Vertex.	
	R.A.	Dec.	R.A.	Dec.	R.A.	Dec.
Kapteyn, Bradley stars . .	85°	−11°	260°	−48°	91	+13
Eddington, Groombridge stars .	90	−19	292	−58	95	+ 3
Dyson, miscellaneous stars of large proper motion . . .	94	− 7	240	−74		
Schwarzschild, Groombridge stars	...	...	...	...	93	+ 6
Eddington, Zodiacal stars . .	103	−11	330	−64	109	+ 6
Beljawski, Porter stars . . .	...	...	...	...	86	+24

In Groningen Publications, No. 19, Professor Kapteyn and Dr. de Sitter give the results of their determinations of the proper motions of 3300 stars from photographic plates prepared by Professor Donner. These plates received their first series of exposures in the years 1897–98, and, after remaining undeveloped for seven or in some cases eight years, were exposed again in 1904–06; the proper motions could then be derived by measuring the small distances between the different sets of images. The probable error of an annual proper motion was found to be not greater than $\pm''\cdot013$—a very satisfactory result considering the shortness of interval. It should be remembered that the object of the determination is not to find the motions of individual stars, but to provide material to be used in statistical discussions of the motions and distribution of the faint stars. For this purpose, also, the publication of a nearly equal number of parallaxes, mainly of the same stars, determined by the same method, is promised by the authors.

It may be noted that in the above investigation only three stars out of the 3300 were found to have annual proper motions exceeding $0''\cdot5$. Professor Turner (*Monthly Notices*, lxix. p. 57), from a

comparison of measures of duplicated plates taken for the Oxford Astrographic Catalogue, finds only 6 stars out of 2822 with annual proper motions greater than 0″·2. Both these results indicate a rather unexpected paucity of large proper motions among the faint stars.

A. S. E.

Star Catalogue.

Küstner's Catalogue of 10,663 *Stars between* 0° *and* 51° *North Declination for* 1900.

The great bulk of the observations for this catalogue were made in the years 1894–1899; revision observations were, however, obtained when needed until 1903. The whole of the observations were made by Professor Küstner himself, and the instrument—the 6-inch Repsold Meridian Circle of the Bonn Observatory—remained unaltered during the comparatively short time over which the observations extended. Seeing that the observations numbered something like 30,000, the task has been a prodigious one for a single individual to have accomplished in so limited a time; it must clearly have required an extraordinary degree of energy and devotion on the part of Professor Küstner. Rather more than 7000 of the stars are contained in catalogues of the Astronomische Gesellschaft, and the hope is expressed that the present work may enable these catalogues to be compared more closely than has hitherto been possible with a uniform fundamental system.

Professor Küstner has investigated the effect of magnitude-equation both in right ascension and declination with great completeness. The effect is in part directly eliminated, since screens were used in observing the fundamental and other bright stars, in order to reduce them in the mean to magnitude 8·5; but in addition the magnitude equation both of the observer and of the fundamental catalogue (that of Auwers) was determined. Professor Küstner's magnitude-equation in right ascension proved to be very small; in declination it was considerably larger. The magnitudes of the stars were estimated at each observation, and, after all necessary corrections had been applied, reduced to the Potsdam scale. The resulting magnitudes are given in the catalogue.

In the case of double stars occurring in the catalogue, measures of the positions and magnitudes of the components were made with an equatorial, thus supplementing the meridian observations.

A. S. E.

The Astrographic Chart and Catalogue.

The annual report of this undertaking has now become little more than a statement of the publications issued during the year. At the beginning of 1908, volume ii. of the Greenwich Section was distributed, which completes the publication of the rectangular co-ordinates of the stars in the region from 64° N. to the Pole allotted

to the Royal Observatory. The conversion of the co-ordinates into Right Ascension and Declination for such of these stars as have been previously observed and catalogued is proceeding. The fourth volume of the Oxford University Observatory Zone has been also published, containing 65,808 stars, which completes the publication of the measures of the stars from Dec. 32° N. to 27° N., and leaves two similar volumes to finish this section. A second volume, numbered Tome iii., containing all the stars between R.A. 6^h and 9^h in the zone Dec. 39° to 47° N., has been issued from the Helsingfors Observatory, which gives equatorial co-ordinates in the complete way explained when the first volume was published in 1904. From comparison of dates, an estimation may be made of the time required to complete the eight volumes, which will contain the catalogue of this zone. Neither Potsdam nor the French Observatories have published any instalments during the year, owing possibly to changes in the Directorships. The reports from the Cape and Melbourne show that the measuring of the stars in the South Pole region 41° to the South Pole is proceeding, and the formation of the catalogue for the remaining parts of the sky 47° to 64° N. Declination, and 3° to 41° S., is proceeding, it is believed, with more or less rapidity, but exact reports of the state of the work will no doubt be presented at the meeting of the Permanent Committee, which is to be held at Paris in April of this year.

The number of enlargements of chart plates distributed up to the end of December last is

Paris	331	San Fernando	165
Algiers	309	Tacubaya	61
Toulouse	158	Greenwich	934
Bordeaux	70		

H. P. H.

Stellar Spectroscopy in 1908.

Nebula.—The nebula HV 15 Cygni lies in the Milky Way, and is remarkable for its considerable wispy extent. It appears to form a boundary, extending over about 2°, between two regions differing much in richness of stars. The work of Max Wolf (*Ast. Nach.*, **178**, p. 379) shows that its spectrum proclaims it to be a gaseous nebula.

Sixth Type of Stellar Spectra.—Professor E. C. Pickering proposes to include stars with peculiar spectra, which cannot be assigned to already recognised classes, in a special class R. He gives a list of 51 stars which are gathered together under one type, which he suggests should be regarded as a sixth type of stellar spectra (*H.C.O. Circular*, No. 145, and *Ast. Nach.*, **179**, 373), and gives in his circular No. 145 a photographic reproduction of spectra of 5 stars. The photograph is not given in *Ast. Nach.*

Classification of Stellar Spectra.—Several papers of interest in this connection have been published in the course of the year. Amongst them we may refer to the following:—

Gibson and Pearson (*M.N.*, lxviii. 415). On correlation of stellar characters.

Franks (*M.N.*, lxviii. 672). The relation between star-colours and spectra.

Franks (*M.N.*, lxix. 106). Analysis of the colours and magnitudes of 3630 stars.

Bell (*M.N.*, lxix. 108). Note on spectral class and stellar colours.

Parkhurst and Jordan (*Astroph. Jour.*, xxvii. 169). The photographic determination of star-colours and their relation to spectral type.

Herr Hertzsprung discusses the stars in the subdivisions *c* and *ac* in Miss Maury's classification of stellar spectra (*Ast. Nach.*, **179**, 373).

Sir Norman Lockyer discusses the general spectra of certain typical stars (β Persei, α Pegasi, ι Orionis, α Canis Minoris) and the spectra (in the green region) of α Cygni, Sirius, Rigel, Capella, and Arcturus (London, Wyman & Sons, 1908).

Studies of Special Stars.—ζ *Ursæ Majoris.*—The brighter component of Mizar was shown by the Harvard College observers in 1890 to be a spectroscopic binary. Herr Ludendorff (*Ast. Nach.*, **177**, 7) has studied the spectrum of the fainter component, and finds it belongs to Vogel's class I α 2. The velocity in the line of sight is $-12{\cdot}5$ km./sec., which is the mean of 14 observations in 1905–07, ranging from $-7{\cdot}9$ to $-17{\cdot}7$. It would thus seem to move similarly to Mizar, Vogel's value for that star being $-14{\cdot}2$ km./sec.

Whilst Herr Ludendorff hesitates to ascribe the large range in his values of the radial velocity to real changes in the star, Professor Frost (*Ast. Nach.*, **177**, 171) regards the changes as real, and records that the Yerkes observers find values between -17 and $+10$ km./sec. This star is accordingly entered in the following section.

ϵ *Ursæ Majoris.*—This star was observed by Vogel in 1889, and its velocity was found to be -30 km./sec. Adams, again, observed it in 1902, and found the velocity to be -9 km./sec., a value which was confirmed by observations at Potsdam in 1903. Mr. Baker, observing at Allegheny in 1907, finds the velocity to be -7 km./sec. (*Allegheny Publications*, vol. i. 23).

α *Orionis.*—Mr. H. C. Plummer has studied the evidence of variability of radial velocity of this star, and concludes that it points to a minimum of about $+18$ km./sec. in 1898, and a maximum of about $+26$ in 1905 or 1906 (*Ast. Soc. Pac.*, xx. 227).

α Persei.—Herr Goos has studied the velocity of this star at the Bonn Observatory (*Ast. Nach.* **180**, 49).

A list of stars having peculiar spectra is issued by Professor Pickering (*H.C.O. Circ.* 143, and *Ast. Nach.*, **179**, 191). It deals with 28 new variables and 6 other stars.

Variable Radial Velocity.—Notes on variability of velocity are given for the following stars :—

ζ Canis Majoris	Lick Observatory	*L.O.B.* No. 146.
τ Puppis	,,	,, ,,
o Velorum	,,	,, ,,
d Carinæ	,,	,, ,,
q Velorum	,,	,, ,,
ν Puppis	,,	,, ,,
ν Octantis	,,	,, ,,
γ Persei	,,	,, ,,
ξ Tauri	,,	,, ,,
θ^2 Tauri	,,	,, ,,
l (53) Eridani	,,	,, ,,
ζ Aurigæ	,,	,, ,,
ρ Orionis	,,	,, ,,
β Canis Majoris	,,	,, ,,
ν_2 Draconis	,,	,, ,,
70 Ophiuchi	,,	,, ,,
111 Herculis	,,	,, ,,
φ Cygni	,,	,, ,,
δ Aquilæ	Potsdam (Ludendorff)	*Ast. Nach.*, 178, 53.
o Andromedæ	,,	,, ,,
9 Camelopardalis	,,	,, ,,
τ Cygni	,,	,, ,,
β Scorpii	,,	,, ,,
ζ Ursæ Majoris (faint ∗)	Frost	*Ast. Nach.*, 177, 171.

It is interesting to note that there is only one case in these 23 systems where the spectra of both components are visible, viz. φ Cygni.

Orbits of Spectroscopic Binaries.—Orbits have been calculated for the following spectroscopic binaries :—

o Leonis	H. C. Plummer	*L.O.B.*, No. 133
β Herculis	,,	,, ,,
ω Draconis	A. B. Turner	,, ,,
α Andromedæ	H. Ludendorff	*Ast. Nach.*, 178, 23
	R. H. Baker	*Allegheny Publns.*, i. 17
θ Aquilæ	R. H. Baker	,, ,, i. 45
η Virginis	W. E. Harper	*Astroph. Jour.*, xxvii. 160
ι Orionis	Plaskett and Harper	,, ,, 272
13 Ceti	P. Fox	,, ,, 372
ψ Orionis	Plaskett	,, xxviii. 266
ι Orionis	,,	,, ,, 274
ι Pegasi	Zurhellen	*Ast. Nach.*, 177, 334
β Persei (Algol)	Schlesinger and Curtiss	*Allegheny Publns.*, i. 25
	R. H. Curtiss	*Astroph. Jour.*, xxviii. 150
	Belopolsky	*Mitth. Pulkova*, ii., No. 22
α Aurigæ	F. Goos	*Inaug. Diss. Bonn*, 1908, *from* 35 *observations at Bonn.*

Herr Belopolsky has studied Algol specially with a view to detecting evidence of dispersion in space.

Professor Frost publishes information relating to spectroscopic binaries under observation at different observatories (*Astroph. Jour.*, xxvii. 161).

Mr. Schlesinger contributes a paper on "The determination of the orbit of a spectroscopic binary by the method of least squares" (*Allegheny Publications*, vol. i. 33).

Mr. W. F. King describes a graphical method of dealing with the same problem (*Astroph. Jour.*, xxvii. 126).

Mr. H. C. Plummer gives a brief summary of various methods used in determining orbits (*Astroph. Jour.*, xxviii. 212).

Mr. Heber D. Curtis gives a similar summary (*Astr. Soc. Pac.*, vol. xx. p. 133).

Herr W. Zurhellen contributes further remarks on the determination of orbits (*Ast. Nach.*, **177**, 321), and also criticises the work of King and K. Laves (*loc. cit.*, 335).

Spectra of the Major Planets.—Striking photographs of the spectra of the planets Jupiter, Saturn, Uranus, and Neptune, compared with the spectrum of the Moon, have been obtained by Mr. Slipher at the Lowell Observatory (*Ast. Nach.*, **179**, 241).

Mr. Slipher also communicates an interesting note concerning the spectrum of Mars (*Astroph. Jour.*, xxviii. 397).

New Spectrographic Installations.—Mr. Plaskett has continued his careful work of studying conditions of star-images in spectrographic work (*Astroph. Jour.*, xxvii. 139).

His experiments confirm the views of Mr. Newall with respect to the size of effective tremor discs and cores. He has further studied the effect of increasing the slit width upon the accuracy of radial velocity determinations (*Astroph. Jour.*, xxviii. 259).

The Publications of the Potsdam Observatory contain two valuable memoirs of recent date. The one by Dr. Eberhard deals with the spectrograph No. IV. (*Publ. Potsd. Obs.*, vol. xviii.); the other, by Dr. Hartmann, shows how much trouble has been experienced in the perfecting of the 80-cm. objective of that observatory, and with what care the testing has been carried out (*ibid.*, vol. xv. ii.).

Standards of Wave-length.—Messrs. Fabry and Buisson contribute a paper summarising their determinations of wave-lengths of iron lines between λ 2373 and λ 6495 (*Astroph. Jour.*, xxviii. 169).

Mr. Pfund describes interesting and important experiments throwing light on the accuracy of results obtained by interferometer methods (*Astroph. Jour.*, xxviii. 197).

H. F. N.

List of Public Institutions and of Persons who have contributed to the Library, etc. since the last Anniversary.

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Batavia, Royal Society of Sciences.
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Geneva, Society of Physics and Natural History.
Göttingen, Royal Society of Sciences.
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Heidelberg, Astronometrisches Institut.
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Italian Geodetic Commission.
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St Petersburg, Imperial Academy of Sciences.
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ADDRESS

Delivered by the President, Mr. H. F. Newall, on presenting the Gold Medal of the Society to Dr. Oskar Backlund.

The Gold Medal of the Royal Astronomical Society is this year awarded to Dr. Johan Oskar Backlund, Director of the Pulkowa Observatory. It is a great pleasure that the duty devolves on me, as your President, to present the Medal to him, and I would at once say with what satisfaction we all join in welcoming his presence among us to-day. We appreciate it very highly that he has not hesitated to travel from Russia in his well-earned holiday in order to be present at our annual meeting.

I almost wish I might call upon him to speak to you with all his authority on his long-continued work, which the Council desire to commemorate, namely, his researches on Encke's Comet. This wish is father to a thought which perhaps some future President may develope: could we not, with great advantage to our science, always call upon our Medallist himself to lay before us the best justification of the award made by the Council? In some such way we should, in seeking to do honour to our Medallists, enhance the honour which we ourselves feel in linking their names with the history of our Society.

After these words, I must allay any fear that may arise in the mind of our welcome guest to-day, and I will at once say that I do not propose to call upon him to speak impromptu on a life's arduous work. I am also in the happy position of being able to assure you that a great part of the latter half of my address is based on Dr. Backlund's own words, without which I could hardly have hoped to be able to cope with the intricacies of the investigation.

Apart from Halley's long-period comet, to the immediate return of which we look forward with such deep interest, probably no comet has been studied with such zest as Encke's comet, the earliest discovered short-period comet.

It was first seen in 1786 by Méchain and Messier, who got two observations only, and were therefore unable to deduce the elements of an orbit. In 1795 Miss Caroline Herschel discovered it again, and it was well observed elsewhere. In 1805 Pons, Huth, and Bouvard discovered it on the same day. It was this 1805 comet of which Bessel showed that its observed positions exhibited distinct deviations from a parabolic orbit. In 1818 Pons again discovered it at Marseilles. At that time it was generally believed that these four discoveries related to four

different comets with parabolic orbits. But in August 1819 Encke—then in his twenty-eighth year, still studying at Göttingen under Gauss, in spite of two spells of active military service as a sergeant-major in horse artillery in the troubled times between 1811 and 1815—Encke showed that Pons' 1818–19 comet moved in an elliptic orbit in a period of about three years, and that the same orbit agreed better with the observed positions of the comet of 1805 than a parabolic orbit. When Encke had pointed out that since 1805 there must have been four returns (period about 1205 days), Olbers at once saw that not only could Miss Herschel's comet of 1795 be an earlier return of that same comet, but also that the two observations made by Méchain and Messier in 1786 could be fitted in satisfactorily with the same calculated orbit.

Encke, in his communications to Bode's *Jahrbuch* for 1822 and the following years, proved conclusively that these various observations actually did relate to one and the same body. By August 1820 (Bode's *Jahrbuch* 1823) he had already freed the orbit of some planetary perturbations, in order to deduce the period as it would be in a purely elliptic orbit, and his calculations led him to the result that the period was diminishing,

1786–1795	1208·122 days	(3 periods),
1795–1805	1207·879 „	3 „
1805–1819	1207·424 „	4 „

and he expressed the hope that future observations would show whether the gradual increase in the velocity is to be ascribed to "the nature of the comet" or to errors in computation.

In Bode's *Jahrbuch* for 1826 (May 1823) comes Encke's first serious consideration of a resisting medium, which Newton had never discountenanced, and which Laplace and Euler had not succeeded in demonstrating. Encke there quotes from a letter of Olbers, written in answer to his inquiries, a passage relating to the possible comparability of the density of the comet and the density of the material of the zodiacal light. And thus, whereas the earlier papers of Encke have titles which refer to Pons' comet —a name which he always adhered to, in spite of the remonstrances of Bode and many others—the title of his last (1858) summary of work on the subject (*Berl. Jahrbuch* 1861, abstracted in English in *M.N.*, xix. 70–75) is "On the existence of a resisting medium in space."

After the discovery of the comet in 1822 by Rümker at Paramatta, the perihelion passages for 1825 and 1828 were calculated on the basis of the existence of a resisting medium; and in 1832 Encke summarised his work in Nos. 210–11 of the *Astronomische Nachrichten*. Airy published in a separate tract a translation of this dissertation, adding a few explanatory notes of his own, and expressing his belief in the validity of Encke's conclusions. In that paper Encke stated his assumption that the resistance of the medium is proportional to its density and to the square of the velocity of the comet, and he supposed the density of the medium to vary inversely as the square of the distance from the Sun, and

accordingly represented the action of the medium on the comet by a tangential force

$$U' = U.k^2\left(\frac{2}{r} - \frac{1}{a}\right).\frac{1}{r^2}$$

where the right-hand member may be considered as made up of three factors, U a constant depending on the resistance, $k^2(2/r - 1/a) =$ the square of the comet's velocity, and $1/r^2$ the inverse square of the radius vector.

This hypothesis was introduced into all the calculations from 1819–1858. And Encke pointed out that the perihelion passage setting out from 1819 occurs earlier on each successive occasion than it ought to do, according to the then existing planetary theory, to the extent of

0·5 days in 1838
2·0 „ 1848
4·5 „ 1858

and in the last-named year the error of 4·5 days would have caused an error of 3°·4 in the geocentric place of the comet. Hence the agreement between the observed places and the places calculated on the assumption of a resisting medium affords a strong proof in favour of the hypothesis.

In later papers, which were summarised by Encke in his last communication published in 1858 in the *Berliner Jahrbuch* for 1861, he showed that if this special expression for the resisting force were replaced by a system of elements in which the mean motion varies in direct proportion to the time, and the mean anomaly in the proportion of the square of the time, the observations between 1819 and 1848 would be equally well represented. The final conclusion of his labours, extending up to the 1858 return, was that the peculiarity in the motion of Encke's Comet consisted simply in a gradual increase in the mean motion, whereas in all other explanations which had been offered the effects to be expected were necessarily of a periodical nature, and would not account for the phenomena.

With respect to this *gradual* increase, we must bear in mind, as Encke himself pointed out, that the comet is faint, and is only observed near perihelion.

No one can read these earlier investigations without feeling uneasy about the elimination of the planetary perturbations. Encke began work with Laplace's value of the mass of Jupiter 1/1067·09, changed it to Nicolai's value 1/1053·92 with great improvement, and eventually adopted the value 1/1047·87. The reciprocal of the mass of Mercury, sometimes of great importance, varied between $3{\cdot}3 \times 10^6$ and $4{\cdot}8 \times 10^6$. I would not here appear to be disparaging the work of Encke; for to him we owe all honour for the thoroughness with which he carried out his investigation, with an exactitude unapproached in any such work at that time.

After Encke's death in 1865, the work was taken up by von Asten, who in his twenty-fifth year had joined the staff of the

Berliner Jahrbuch in 1867. Together with Dr. E. Becker, he prepared the search ephemerides for 1865 and 1868; and whilst Dr. Becker worked out the perturbations of Saturn, von Asten calculated those due to the Earth. Von Asten was appointed to a post at Pulkowa in 1870, and thus the heritage of Encke's Comet was carried to Russia.

At Pulkowa, von Asten decided to found an investigation of the theory of the motion of Encke's Comet on the basis of absolute perturbations. Hansen's "Mémoire sur le calcul des perturbations qu'éprouvent les Comètes" had been published in 1850, having gained the prize of the Paris Academy. In it he had shown how the convergency of the series which represent the perturbations may be increased by adopting a principle of partition, according to which the co-ordinates of the comet are expressed by different variables ("partial anomalies") in different portions of the orbit. Where the comet approaches closely to a planet, computation of special perturbations must be resorted to. Von Asten utilised in part Gyldén's suggestions, and in 1872 he published his memoirs on the absolute perturbations of the first order for the portion of the orbit between the true anomalies 170° and 180°, *i.e.* close to aphelion. He then changed his procedure, however, and after computing the special perturbations since 1848, he published his laborious work in 1878. It was in this same year 1878 that von Asten died, in his thirty-sixth year.

From that time up to the present our Medallist, Dr. Backlund, has devoted himself to work on Encke's Comet, undeterred in later years by increasing administrative labours.

Dr. Backlund was first impelled to take up the investigation of the motion of the comet by the unsatisfactory results obtained by von Asten when he attempted to represent it with a constant value of the acceleration of the mean motion. In his memoir "Untersuchungen über die Bewegung des Enckeschen Cometen 1871–1881," he proved that the acceleration of the mean motion had changed before 1871, the change of the acceleration being a diminution. In an appendix to that paper he supposes that the force which resists the motion of the comet is of the form KV^m/r^n, where K is a constant, V is the velocity, and r the radius vector of the comet. He then showed that the observed relation between the variation in the mean motion and the eccentricity is satisfied by any positive values of m and n, such that $2 \leqq m+n < +\infty$. The values $m=2$, $n=2$ (which were Encke's values), admit of a very convergent development of the periodical variation in the mean anomaly, so that it is enough to retain only the first term.

The next apparition, 1884–5, corroborated the results, and Dr. Backlund then decided to revise the whole theory.

When Dr. Backlund undertook the definitive solution of the problem, the position was as follows:—

Encke had determined from the observations the constant of resistance in the expression for his hypothesis of a resisting medium. In his calculations he then took account of the theo-

retically derived values for the changes in the mean motion and the eccentricity. Von Asten introduced in his discussion of the sixteen apparitions 1819–1868 a more direct way, by determining the changes which the mean motion and eccentricity underwent during a single revolution of the comet, independently from one another. By the results obtained in this manner he seems to have fully convinced himself of the correctness of Encke's hypothesis, which involves the idea that the resistance-constant, in so far as it is independent of the comet itself, possesses the character of a real constant. This is probably the reason why von Asten was led to attribute the discovered change in 1869 to perturbations from the minor planet Diana. At any rate, with this hypothesis he attempted to explain why the apparitions of 1871 and 1875 could not be connected by simple reference to Encke's hypothesis. But Dr. Backlund found that the apparitions 1871–1881 contradicted von Asten's hypothesis, and rather suggested that the constant of resistance had changed. He therefore took the masterly view that the only way to get a true foundation for further researches was to calculate the perturbations afresh right through from 1819.

Fortunately, in this colossal undertaking he received the support of the Academy of Sciences of St. Petersburg; and the generosity of M. E. Nobel enabled him to engage assistants and to overcome the task of calculating the perturbations. The St. Petersburg Academy published the calculated perturbations *in extenso*, and they form six noble memoirs, dealing with the perturbations of the planets Mercury, Venus, Earth, Mars, Jupiter, and Saturn from 1819–1891, embracing 22 revolutions and 23 apparitions of the comet.

The calculations are of unusual complexity, which arises partly because the perihelion lies within the orbit of Mercury and partly because the comet approaches Jupiter so closely at times as to be within one astronomical unit from it.

Once in possession of trustworthy values of the perturbations, Dr. Backlund could pass on to the investigation of the comet's motion. A preliminary discussion showed that it was impossible to connect all the twenty-three apparitions under one hypothesis in regard to the acceleration. The whole interval was accordingly divided into three parts—1819–1858, 1858–1871, 1871–1891.

Treating the first period (Encke's range), Dr. Backlund introduced in the eighty-eight equations of condition, formed by comparing theory with observation, the following as unknowns: corrections to the elliptic elements; the increment μ' in 1200 days of the mean motion; the masses of Mercury and Venus.

The main results (1819–1858) were—

1. $\mu' = 0''\cdot1263$
2. The mass of Mercury, $m_{\mathrm{☿}} = \dfrac{1}{9\cdot7 \times 10^6}$
3. The mass of Venus, $m_{\mathrm{♀}} = \dfrac{0\cdot975}{401839}$

In order to control the small value of mass of Mercury, the hypothesis and equations of condition were varied. The periodical variation in the mean anomaly derived from the form KV^m/r^n was considered and omitted; the quantities of second order coming from the acceleration of the mean motion were considered and omitted. The apparition 1838, in spite of numerous good observations, was found in all solutions to show abnormal disagreement, and so was excluded in one solution. Then all apparitions which were observed only after perihelion were excluded. In one solution, only the normal places formed of observations made in the neighbourhood of perihelion when the nucleus was visible were utilised. Lastly, the apparitions 1819–1842 and 1842–1858 were treated separately. All these varied solutions gave practically the same value of the mass of Mercury.

Nevertheless, Dr. Backlund's mind was filled with suspicions because the outstanding errors in O—C of the normal places were large. His representation of the observations did not seem better than Encke's, in spite of the almost exact values of the perturbations. The probable error of one normal place varied in the different solutions between $\pm 12''$ and $\pm 16''$, being nearly twice as great as those derived from the observations direct.

A closer examination of the residuals led to the discovery of their periodic nature; and when a periodic function $\eta \cos \psi$ was applied to the mean anomaly with a period of ten years, it was found that η had the value $+4''{\cdot}04$. The solutions were repeated with this value, and the results were then found completely satisfactory. The mass of Mercury came out the same, and the probable errors of the normal place lay between $\pm 4''{\cdot}5$ and $\pm 6''$—quite compatible with the quality of the observations.

The next interval, 1858–1871, affords only three apparitions, 1862, 1865, 1868, which can be connected supposing μ' constant. Three apparitions are needed to determine M (mean anomaly), μ and μ'. They are not sufficient to determine a small change in μ'. The derived value of μ' is about $0''{\cdot}08$. About 1868, μ' again changed in value, and then remained constant, so that the seven apparitions 1871–1891 inclusive could be connected.

The last interval, 1871–1891, was dealt with in two ways. Firstly, before introducing the mass of Mercury into the equations of condition, the interval was divided into two parts, 1871–1881 and 1881–1891. During each of these the perturbations of Mercury were insignificant, $+8''$, $-6''$ in the mean anomaly; hence μ' could be determined almost independently of an error in the assumed value of the mass of Mercury. Both parts gave nearly the same value of μ'. Secondly, having established the constancy of μ' throughout the interval, Dr. Backlund combined the seven apparitions 1871–1891, and determined the mass of Mercury. The result was $1/9{\cdot}745 \times 10^6$, which agrees very well with the value deduced from the period 1819–1858. The value of μ' came out equal to $+0''{\cdot}066339$—about two-thirds of its value for 1819–1858. The periodic function $\eta \cos \psi$ has not been introduced here, the

interval, twenty years, being small, and the observations being well represented. The probable error of a single normal place is here only $\pm 3''\cdot 3$, which would be slightly reduced by the empirical correction $\eta \cos \psi$.

No attempt was made to determine the mass of the Earth directly. The mass assumed was that corresponding to the solar parallax $8''\cdot 80$. Dr. Backlund, however, compared residuals for the values $8''\cdot 74$, $8''\cdot 80$, and $8''\cdot 86$, and found them least for $8''\cdot 80$.

The main results of the researches here summarised (1819–1891) may be given thus:—

1. A very satisfactory representation of the observations of Encke's Comet is obtained by assuming an acceleration of the mean motion. The acceleration was on an average constant during 1819–1858, diminished in 1858 and in 1868, and was again constant 1871–1891. In addition to these changes a well established periodic change occurs at least in the interval 1819–1858.
2. The mass of Mercury appears to be very well determined, nearly identical values being given by two wholly independent determinations. The value 1/9,700000 must be considered as a close approximation to the truth.
3. The mass of Venus is possibly less than the assumed value 1/401839.

As an independent proof of the elements of the comet, Dr. Backlund compared the system derived from 1871–1891 with the observations of 1894–5. In his memoir "Vergleichung der Theorie des Enckeschen Cometen mit den Beobachtungen 1894–5," published by the Academy of Sciences of St. Petersburg, 1904, he showed that the agreement between theory and observation was so close, that there was no need for any change in the elements and masses.

Since 1894 there have been four more apparitions, and Dr. Backlund has in the past year deduced the perturbations 1891–1908 rigorously. The calculations have, I believe, only been completed in the last month, and they show that at the perihelion passage in 1895 the acceleration μ' is again diminished, and has a value about $0''\cdot 042$. And up to 1908 there appears to be no further change. The memoirs dealing with these calculations are now in the press.

In the *Bulletin astronomique*, 1894, Dr. Backlund gave a *résumé* of his work to that date, so far as it related to the determination of the mass of Mercury and the acceleration of the mean motion of the comet. He put the acceleration in the form

$$K = K_0(1 - \gamma)$$

where K_0 was a constant, and γ is equal to $\frac{m + 2n - 1}{2}\left(\frac{\Delta a}{a_0} + \frac{\Delta k'}{k'_0}\right)$, where m and n are defined by the assumption that the resisting force is of the form KV^m/r^n. He then shows that

(1) the observed relation between μ' and ϕ' (the change of eccentricity in 1200 days) requires that $2 \leqq m + n$;

(2) the observations require that the terms of second order in μ' should be very small, and this is expressed thus—

$$m + 2n - 2 \text{ must be a minimum ;}$$

(3) it can be shown that the perturbative force producing μ' is active chiefly in or near perihelion.

If $n = 0$, *i.e.* if the resistance is independent of the distance of the comet from the Sun, then the value $m = 2$ makes the expression in (2) vanish and the condition (1) is satisfied. Dr. Backlund has considered the hypothesis that the comet crosses a meteoric ring in the neighbourhood of the perihelion ; but he rejects it as improbable in many respects, and as incapable of explaining many particulars. He points out that the greatest outstanding errors (O—C) occur in the perihelion passages in 1828, 1838, 1848, which were years of great sun-spot activity. About 1858 the first abrupt change in the acceleration μ took place, and 1860·1 is registered as a year of maximum solar activity. The change in 1868 is not far from the maximum of 1870 ; and lastly, the well-determined abrupt change of 1895 is close to the maximum in 1894. It seems that these coincidences can hardly be mere chance. But Dr. Backlund regards his task as completed when astrometry in his hands has been made to deliver up all the facts at present attainable with respect to the kinematics of the comet. We can well imagine with what satisfaction Dr. Backlund views the disappearance of the long outstanding difficulties in regard to the derived mass of Mercury, the constancy of which offers such a splendid guarantee for the accuracy and trustworthiness of the whole investigation.

I hope I have said enough to convince you that Dr. Backlund has applied himself to this difficult research with a devotion and a success that rightly make us desire to express our respect in the highest degree in our power.

Dr. Backlund :—In handing this Medal to you, I wish to say, on behalf of the Society, how much we admire your scientific achievements, and how much we feel honoured in linking your name with the history of our Society.

In presenting the Jackson-Gwilt Medal to Mr. Philibert Melotte, the President spoke as follows :—

I have now another pleasant duty to perform, namely, to announce to you that the Council have awarded the Jackson-Gwilt Medal to Mr. Philibert Melotte, of the Royal Observatory, Greenwich, for his discovery of the Eighth Satellite of Jupiter.

I feel confident that the action of the Council will meet with the approval of the Fellows. For not only have we all felt the thrill of keen pleasure at the brilliant discovery of this tiny object, which is proving to be of immense interest from a theoretical point of view ; not only have we been glad that it has been discovered at the Royal Observatory, where it has received instant attention from the Astronomer Royal and from men like Mr. Cowell and

Mr. Crommelin; but most of all we have rejoiced that it has been the reward of the patient work, the devotion and great skill of Mr. Melotte.

We all recognise how the taking of a photograph is only the beginning of the astronomer's work. There follows the scrutiny, directed not only to the acceptance of the photograph as suitable for measurement for the primary object for which the plate was exposed, but also to the deciding whether the plate happens to contain unexpected evidence anywhere on the whole of its surface. Mr. Melotte recognised that if by taking photographs of the sixth and seventh Satellites he could confirm the brilliant discoveries made in the bright skies of California, and applauded all the world over, he could also make fresh discoveries. Those who have seen the tiny speck on the photographic plates have wondered at the skill and insight that have enabled Mr. Melotte to decipher the records and hunt out this satellite of the 17th. magnitude.

As I have referred to the work of other members of the staff at Greenwich as contributing to the interest of this new discovery, I feel sure I shall touch a chord of sympathy, if I add that probably no one recognises more than Mr. Melotte how much is due to his faithful fellow-worker, Mr Davidson; and I am also sure that no one will join more heartily than he in our hope that the next astronomical capture will fall to the lot of Mr. Davidson.

We have read with great satisfaction how, after the return of Jupiter into favourable position for observation, and on the earliest opportunity afforded by a bright night with a perfectly dark sky, Mr Melotte has succeeded again in photographing the satellite, which has been found close to the position indicated by the orbit calculated last year by Mr. Cowell and Mr. Crommelin. It has been followed on several nights.

Thus Mr. Melotte has established his new satellite firmly in the history of astronomy. We wish him prosperity in his future work, and shall look forward with assurance to his gaining fresh harvests for our science, and recognition of his devotion and skill.

I would now beg your indulgence while I speak of other matters. It has been our custom for years past to confine the procedure of our Annual Meeting to the Report of the Council, and to the address in which the President lays before the Society the grounds on which the Council has made the award of the Gold Medal. In conversation with many Fellows, including many members of the Council, I have gathered that the view is held in many quarters that from time to time the President might with advantage make the Annual Meeting an opportunity for a brief address on some subject of his own choosing, provided that we could avoid stereotyped action, which might easily come to impose an unnecessary tax not only upon the President in the preparation of such an address, but also on the Society in listening to it.

The aim of the Report of the Council is directed to furnishing notes on accomplished history, and in general the notes deal with

matters of recent history. It seems that even thus there is room for something of the nature of a more comprehensive historical review from time to time. Such a review could scarcely be compiled by a body of men like the Council; for corporate action is in general conservative, and if a corporate review were given it would tend to take stereotyped form.

Such a result might be achieved without danger of becoming stereotyped if it were made optional for the President at any time to offer an address on some special branch of our large and growing subject, compiled from a special point of view, whether retrospective and historically suggestive, or prospective and speculatively suggestive.

Addresses from our Presidents, some of them mathematicians, some of them observers, some of them combining both bents, would tend to define lines along which mathematical Fellows might be drawn to combine with observing Fellows, to the great advantage of our science. No one will deny the importance of bringing together in education minds that have different characteristics, —minds that have pre-eminently the power of symbolic treatment, with minds that are conspicuous in having the instinct of scientific observation. Herein lies one of the grand advantages of college life in a university. Our Society has opportunities different from those of universities. It can serve as a meeting ground, where the mathematician can profitably combine with the observer.

Now, a suggestion of this sort may be worth nothing, and may come to nothing. The more numerous the men engaged in discussing the pros and cons of putting the suggestion into practical form, the more nearly equal will the votes for and against a given line of action be. It has seemed to me, therefore, that I should offer myself as the vile body for experiment; and in doing so I have had to overcome great diffidence for the sake of making a beginning, which might serve either as a sign-post or a tombstone. It is my hope that the Council, who are not to be held responsible for my rash action, will forgive their President for devoting his last hour of office to departing unbidden from an old tradition. It is my hope that future Presidents may perhaps from time to time be willing to use my action as a precedent for speaking freely at the Annual Meeting. It is my hope that no President will feel it in any way incumbent upon him to speak if speech would be an unbearable or unwelcome burden.

I propose to lay before you an aspect in astrophysical questions. I beg you will treat it with forbearance, for it is laid before you in the midst of work not in any sense completed, rather with a plea for co-operation in the attack.

The aspect which I would propose is this:—Can it be that the main characteristic spectroscopic phenomena of the Sun and the Stars are dictated mainly by matter continually streaming in from without, and not mainly by matter brought from within the body of the Sun and the Star?

My remarks will therefore deal not only with spectroscopic features, but also with matters relating to the dynamics of the solar system.

For years past the work of the classification of stellar spectra, inaugurated by Secchi, and carried on by Vogel, Huggins, Pickering, Lockyer, Schuster, and Hale, has been dominated in large degree by the empiricism handed down to us by Secchi. The advance has been barred in the way for the physicist who has attempted to make his laboratory experience rhyme with the stellar phenomena. The chief obstacle in my own mind has lain in the difficulty of reconciling two requirements: (1) an *extended* atmosphere round a sun or star, required for marshalling the inconsistencies in the behaviour of broad and narrow lines which in stellar spectra are taken as criteria for the order of the evolution of the stars; and (2) a plausible mechanism for avoiding the rapidity with which the shallow atmosphere of a sun or star increases in density inwards in consequence of the huge intensity of gravity at the surface.

The physicist wants (unless I have missed points which may be obvious to others) a far more extended atmosphere round the radiating star than the usually accepted gravitational theory will allow. An extended atmosphere would give greater latitude in attempts to account for peculiarities in stellar spectra, of which probably one of the most striking is the narrowness of the metallic lines.

Let me put the matter broadly thus:—

The procedure adopted generally in classifying stellar spectra starts with the assumption that the blue stars are in the early stages of their development and relatively diffuse. The characteristics of their spectra are broad and strong hydrogen absorption-lines, broad and strong helium absorption-lines, and narrow and feeble metallic lines.

Then, after many stages exemplified by relatively small numbers of stars, the yellow or solar stars are reached. In their spectra the most prominent lines, gauged by the same criterion of breadth and strength as is used in the blue stars, are the calcium lines H and K. They are accompanied by numerous marked but narrow metallic lines.

When the attempt is made to arrange the typical spectra which are intermediate between the spectrum of a typical early blue star and that of a typical yellow solar star, it is found that the order of spectra depends on the criterion adopted. If we seize on the difference in the appearance of the hydrogen lines in the first and second types as the criterion, we have to begin with broad hydrogen lines, and arrange the intermediate spectra in order of decreasing width of these lines till we reach the narrow and relatively inconspicuous hydrogen lines in the solar spectrum. We find irreconcilable inconsistencies in the behaviour of the lines of elements like Mg, Na, and we have at once to recognise the fact that the selection of the breadth of the hydrogen lines as a criterion in arrangement is arbitrary, and merely dictated by the convenience

of utilising an empirically discovered characteristic of certain stellar spectra. When we come to deal with spectra of the third and fourth types, we find ourselves suddenly adopting an entirely new criterion, based on the appearance of bands in the spectra. In fact we seem unconsciously to reserve for ourselves the right to pick out of a multitude of criteria now one, now another, without ever consistently searching for binding relations between the criteria, and rigorously following them out to their inevitable conclusions. We refuse to admit that it is the star that exercises seemingly eclectic choice, and commits itself in general to a fixed and constant type of spectrum—full of apparent inconsistencies.

Now, in dealing with the spectra of sunlight coming from different parts of the Sun, such as the limb, the centre of the disc, sun-spots, bright faculæ, dark mottlings, prominences at the limb and on the disc, we find differences of just the same sort as are characteristic of stellar spectra. And when our mode of search for interpretation is based on what we regard as knowledge derived from stellar spectra, it is necessary to assure ourselves that we are on safe lines in our interpretation of stellar phenomena. For my own part, I find myself in as great difficulties in reconciling criteria in Hale's spectroheliograms of the Sun as in the stellar spectra. Briefly, it seems to me that many of the difficulties of reconciliation would be evaded if we felt at liberty to give up the constraint involved in the idea that the atmospheres of sun and of stars are such as would be formed round masses in *empty* space—masses that have *finished* their gravitational collecting of matter.

The Sun is a body which we believe to have been formed by the gravitation of matter diffused through an immense region of space. In process of the falling together of its gaseous material, a stage is reached in which the increase of temperature is so great that the outer layers radiate light and heat into the ether. The energy emitted in radiation leaks out of the gravitating matter into the ether. This leak takes place mainly in the layers of the photosphere, under conditions so tumultuous that we have confused radiation as from a solid incandescent body, and the result is that the spectrum is continuous ; all wave-lengths are represented.

The solar radiation is maintained at its observed value, involving something of the order of 130,000 horsepower per square metre of the Sun's surface. The mechanism of maintenance, as far as we are able to visualise it, depends on the existence of radial convection currents which carry the energy from within the body of the Sun to the surface of leak—the photosphere.

Schuster gives the requirements of the mechanism in this form :—In every second of time a fresh layer of hot gaseous matter will have to be brought to the radiating surface, a layer of thickness 370 metres (1230 feet) if the gas is at atmospheric pressure. And the matter brought up in the preceding second must be got out of the way when it has delivered up its heat and has become completely cold.

It is outside of this photospheric surface that the gaseous

matter rests which produces the spectroscopic characteristics of the Sun and the stars. Hitherto, so far as I am aware, we have been ready to regard this reversing layer as something provided from the Sun or the Star; we have in fact dealt with each Sun as if it had finished its gravitational collection of matter from space, and was making its spectroscopic display out of matter already permanently in its possession.

In the aspect which I propose, these spectroscopic characteristics are provided by the rarefied gases which are continually arriving upon the surface of the Sun or the Stars from the space surrounding them, drawn in by the constantly active gravitational attraction of these massive bodies.

Before I go into the question of numerical relations, let me call attention to one or two other points.

In a huge extended nebula like that in Orion, our apparent inability to detect undoubted change in the form of the luminous outlines may turn only upon the shortness of time that has elapsed since we have got trustworthy records of the form. But in the thirty years that have passed since photography became the valued servant of the astronomer, no change is detected even in the less conspicuous parts, nor are we able to say that the visual observations made and recorded many scores of years previously give evidence of change in so conspicuous an object as, for instance, the scimitar in the Orion nebula. How are we to conceive of the mechanism required for the provision of the energy radiated by these immense regions of luminosity?

Generalising from an observation of a remarkable phenomenon which I had the good fortune to make in the year 1895,* I was led to the view that the form of the conspicuous features of a nebula might turn upon the existence of very complicated surfaces round huge masses of matter distributed irregularly within the enormous limits of the nebula, surfaces at which gases and vapours still streaming in from outside changed their condition of molecular aggregation in a manner that involved the breaking up of the aggregates and the concomitant emission of luminosity. It is only necessary to suppose that this dissociation takes place most easily at surfaces which provide the proper conditions of pressure, etc., and that the substance dissociated is endothermic.

With increasing pressure, the frequency of collisions between molecules or aggregates increases, until a state of affairs arises in which the frequency of the collisions experienced by a molecule or aggregate coincides with the frequency of some natural period in the system. When this moment is reached the system may break up, and the disrupted system rearranges its parts with the emission of light.

Numerically, I found in my experiments with rapidly alternating electric fields that when the frequency of alternation of electrical fields came to be of the order of one hundred million per second, intense luminosity was produced in the gas in a vacuous bulb

* *Proc. Camb. Phil. Soc.*, Vol. ix. p. 295.

subjected to Professor Sir J. J. Thomson's method of electromagnetic electrodeless discharge. And the phenomenon of luminosity could be produced in certain mixtures of gases when they were brought by the process of "compression" from an exceedingly attenuated condition into a very slightly less attenuated state, the change in density being such as involved a change in frequency in collision frequency passing through frequencies of the same order, viz. one hundred millions per second.

The generalisation that I was tempted to make is that in a nebula there is a complicated surface (determined by irregularly distributed matter within), at which gas, streaming across from without, passes through those conditions (of collision frequency perhaps) which result in disruption of molecules or aggregates, and give rise to luminosity with the bright-lined spectrum connected with gaseous nebulæ. We might describe the surface as an isobaric surface if we were certain that change of pressure was the only condition that we need vary to produce the observed luminosity. The convolutions of this complicated surface of critical nature (I will refer to it in this address as a critical surface) determine the irregular forms of luminosity in a nebula as we perceive it in projection on a plane normal to the line of vision. Such a surface will change but slowly, and it seems therefore to afford an intelligible mechanism for the continued emission of luminosity over wide regions of space with but small changes in form.

Another point I wish to refer to. Our familiarity with cometary phenomena seems to render us more or less obtuse to the wonderment, that the continuous glow in the tail of a comet throughout immense regions of space ought to rouse in our mind. When Bredichin points out that the glowing may be going on simultaneously through the whole of a tail of a comet whose axial length is as much as an astronomical unit say one hundred million miles, and whose cross diameter is as much as a million miles, we ought to awake to the importance of the part played by extremely attenuated matter in space in the production of luminosity under unconquered circumstances. Who knows whether, if we could discover a method of disrupting gases and vapour in ultra vacuous spaces artificially maintained on earth, we should not have a method of artificial illumination as economical as that of the glowworm, and as brilliant as is needed for our nocturnal life? Here is a theme that should stir up the most commercial mind in the support of astronomy. But I want here only to point to a striking instance that shows how space usually held to be free of matter may declare its presence by the most magnificent manifestations.

Is the changing radius of the envelope of Encke's Comet as it approaches the Sun determined, like the depth of the Crookes' layer and the confines of the negative glow in our vacuum tubes, by the free path of molecules round the nucleus of the comet?

If so, the recorded dimensions of the envelope as the comet

approaches the Sun from a distance of 216 solar radii to a distance of 73 solar radii from the Sun's centre point to a diminution of the molecular free path from 63,000 kilometres to 2400 kilometres. And if we may extrapolate from our laboratory experiences that deal with pressures a thousand million times higher, then the phenomena of Encke's Comet show that our physicists and electrical engineers, if they wish to provide us with "comet-glow lamps," will have to devise methods of producing electric discharge in vacua wherein the pressures range between $2{\cdot}2 \times 10^{-15}$ and 58×10^{-15} atmospheres, and the number of molecules per c.c. is of the order of 10^5.

Then again, with respect to the corona, can we be so self-centred as to think that the solar corona is the only one in the universe? We must be ready to admit the existence of similar appendages to most of the other stars. Of our own solar corona we have come to recognise that it waxes and wanes both in its extent and its distribution. It portends the existence, in varying amounts, of gas and dust round the Sun to a degree that clamours for the extension of limits of atmosphere.*

Here, then, are a few reasons for looking into possible practical ways of justifying the belief that in space, especially in the neighbourhood of suns, there must exist matter forming extended atmospheres. Such atmospheres cannot be statically constituted; and we are driven to imagine them as dynamically maintained by some process by which the gas is either constantly being pushed out from the Sun, or constantly streaming in upon it in quantities sufficient to justify the idea of a quasi-permanent supply.

Just as the continued maintenance of a candle flame depends upon the continued survival of a definite condition of luminosity in a constantly passing supply of vapour, so too the continued maintenance of the glowing corona and the zodiacal light, the quasi-permanent tail of a comet, the permanent spectroscopic characteristics of the Sun and the Stars, may be conditioned by phenomena occurring in a constantly renewed supply of gas and vapour.

Summarising, I may say that there appears to me to be a case for believing that we pass from extended nebulæ where the luminosity is maintained over vast irregular surfaces round dark masses, by gradual steps of transition, till we arrive at single suns, each so far advanced as to have condensed to the stage of having a radiating photosphere and a concentric critical surface or surfaces, wherein originates the characteristic stellar spectrum. [I should add that it is not yet at all clear to me that the photosphere and critical reversing layers are necessarily distinct and separated.]

Let me now, as briefly as may be, go into numerical relations, and show to you some reasonable grounds for justification of the aspect that I wish to lay before you.

For the moment let us neglect the details of the mode of in-streaming of gas, the passage from the tumultuous whirl of planet molecules round the Sun, into the quiescent settling of the gas upon

* *Proc. Roy. Inst.*, 9th February 1906.

the surface of the Sun. The question is—Can we justify the idea that there is enough matter constantly—second after second—settling upon the Sun?

This means continuous accretions, continuous growth of the mass of the Sun; and it looks as if we should upset all the periods in the solar system, quite apart from the action of a resisting medium. I will lead you along the path I have myself gone, though there are probably better and shorter cuts.

For the period of a planet of mass m describing an orbit of mean radius a round a sun of mass M in a period t, we have the relation

$$(m+M)=\frac{4\pi^2a^3}{t^2}.$$

Suppose the mean distance remains unchanged, whilst the mass of the sun increases by ΔM, we have, neglecting m and Δm,

$$\frac{\Delta M}{m+M}=-\frac{2\Delta t}{t}.$$

This means that a certain percentage change in the mass of the Sun will produce half that percentage change in the period of the planet.

Consider our Earth. Let us allow that we should fail to detect, from our best modern observations since Bradley's time, a change per year in the length of the year of one thousandth of a second of time, that is, 1 part in $31{\cdot}5\times10^9$, since there are $31{\cdot}5\times10^6$ seconds in a year.

Such a change in the length of the year would be brought about by an addition to the Sun's mass equal to 2 parts in $31{\cdot}5\times10^9$ in each year.

Now the Sun's mass is approximately 2×10^{33} grammes. Hence to change the length of the year by $\frac{1}{1000}$ second by increase of the Sun's mass in one year, we want a quantity of matter

$$\Delta M=\frac{M\times2}{31{\cdot}5\times10^9}=\frac{4\times10^{33}}{31{\cdot}5\times10^9}=126\times10^{21}\text{ grms. per year,}$$
$$\text{or } 4\times10^{15}\text{ grms. per second.}$$

That is to say, since a million grammes are about equal to 1 ton, we could have four thousand million tons of matter going into the Sun in every second without being able to detect it, by virtue of a change in the length of the year or an acceleration in the Sun's longitude.

Before developing this, let me pause to call to your recollection that Mr. Cowell's recent work has led him to believe that a comparison of ancient and modern eclipses—phenomena the most likely to disclose a change in periods—indicates that they are best co-ordinated by allowing that there is a not inconsiderable acceleration of the Sun's longitude, apart from an acceleration of the Moon's node. Mr. Cowell's investigations lead him to a value of the acceleration of the Sun's longitude of about 3″ or 4″ per century per century, and he has pointed out that the existence of a resisting medium affords a possible explanation of such an acceleration in

the Earth's centennial motion,—an explanation that does not contravene gravitational theory. The aspect that I am now laying before you, demanded by entirely different considerations, offers another possible explanation, which, as far as I can see, is as blameless of unwelcome contravention as Mr. Cowell's—it is clear that the two aspects must be in some way combined properly.

A secular acceleration of the Earth in its orbit of 1″ per century per century corresponds to an increase per century of 2″ in its centennial motion. This corresponds to an annual change of $\frac{1}{400}$ second in the length of the year. Hence it would appear that the change of 0·001 second, which I have made the basis of my calculations, is far below the change which Mr. Cowell's investigations indicate as likely to have actually taken place. My estimate of undetectable change may therefore be taken to be a "conservative" estimate and (in the words of one of my correspondents) eclipses show five or six times as much change if Mr. Cowell is right, whilst, if Mr. Cowell is wrong, eclipses are not good enough to show anything numerically definite. For my own part, I would say that Mr. Cowell's masterly investigations go far to show that the door which the astrophysicist wants to have open does not seem to be irrevocably barred. And in this first presentation of a new aspect it is enough to remember that Mr. Cowell's work points to an acceleration, not a retardation, of the Earth in its orbit.

Let us now consider this estimate of the undetectable accretion of the Sun's mass, 4×10^{15} grammes per second. It amounts to 126×10^{21} grammes per year. It sounds a large quantity. But if we regard our Earth as the quarry from which the material had to be supplied, we should have a source that would last for fifty thousand years.

Now let us suppose that this maximum undetectable quantity contributed only one millionth part in the form of gas (or molecular matter, of dimensions small enough to escape the repelling action of light pressure) which settles on the Sun. Further, let us suppose that another millionth is contributed in the form of splinters and dust, which are driven outwards again by the repelling power of light, and let us assume that only a fraction of the rest penetrates to the Sun as lumps of matter (unsplintered stones and rocks), whilst the rest escapes eventually from the neighbourhood of the Sun by orbital motions.

Even thus, it seems to me, that we should have enough to give us, with Schwarzschild's radiative equilibrium,* an effective atmosphere for the Sun with considerable effective extension.

The light-driven dust, if present in the quantity just mentioned, would provide us with swiftly moving particles to the number of 30 particles per square centimetre of the Sun's surface per second, each of diameter equal to one-tenth of the wave-length of light and of specific gravity 5·5.

This dust is driven radially across the whirl of circulating gas; and I calculate that if there were no resistance to their passage,

* Schwarzschild, Nachr. Göttingen, 1906, Heft I.

the velocities attained under the repulsion of the Sun's light would be enormous. Thus before the limits of the observed corona were reached they would have acquired a velocity of 572 kilometres per second, multiplied by the factor $\sqrt{(n-1)}$, where n is the ratio of the repulsive action of light to the attractive force of gravity. By the time that they reached the Earth's orbit—$72/\sqrt{(n-1)}$ hours after leaving the Sun's surface—they would have the velocity $606 \times \sqrt{(n-1)}$ kilometres per second.

Is anyone who is familiar with the phenomena and theory of comets' tails prepared to say that the repulsion of those tails is not simply a phenomenon indicating the existence of this constant radial outstreaming of dust, rendered manifest by the glowing of the vapours set free by the nucleus of the comet, possibly under the influence of the incessant bombardment by the dust? Encke's Comet takes forty-two days to pass from one end of the latus rectum of its orbit to the other. The dust, as I have said, takes $72/\sqrt{(n-1)}$ hours to pass from the Sun to the Earth's orbit. Does the luminous gas constitute itself a straw to show which way the dust-wind blows? Are Bredichin's comet-tails picked out by some hidden power of hydrogen to be carried out and rendered luminous only by the most swiftly moving dust particles, whilst the hydrocarbons are caught only by the slower moving particles? This is a matter that could best be decided by observation and measurement of the forms of comet-tails about perihelion.

If all the 4×10^{15} grammes per second that I am postulating as undetectable from the point of view of the lengthening of the year were to settle in upon the Sun in gaseous form, it would provide at the visible surface of the Sun a stream which, if it all consisted of air at 0° C., would be at a pressure of 50×10^{-6} atmosphere, settling in at a rate of 1 cm. per second.

If it were all hydrogen at 0° C. the pressure would be $\frac{1}{2}$ mm. of mercury, settling in at a rate of 1 cm. per second.

In order to get a rough idea of the masses involved in maintaining a supply of this magnitude, let us suppose that the supply were continuous, and were distributed in a sphere concentric with the Sun with a density inversely proportional to the distance from the Sun; then the mass within the Earth's orbit would be ten times the Earth's mass, and would last for half a million years, if it all settled in at the velocity 1 cm. per second. The pressures and densities would, however, be inversely proportional to the speed of convergent settling on the Sun's surface. And so the distribution of mass of this continual supply remains indeterminate till we know the speed of settling. Whereas the usual problem is to determine the conditions of continued existence of a system, here the problem is to investigate the rate of precipitation of a system of molecular planets circulating round the Sun, and continually replenished by new arrivals.

Seeliger* has shown that if the matter which produces the zodiacal light were distributed in two disc-like coextensive homo-

* Seeliger, Sitzber. München, 1906, p. 595.

geneous ellipsoids round the Sun, the one in the ellipticity $10 (= \lambda = \sqrt{(a^2 - b^2)}/b)$ extending to a distance 0·24, and the other of ellipticity 5 extending to a distance 1·20, then the outstanding deviations of secular variations in the orbital elements of the inner planets would be explained satisfactorily, if the density of the inner ellipsoid were of the order 3×10^{-11}grm./cm.^{3}, whilst that of the outer were of the order $0{\cdot}4 \times 10^{-14}$ grm./cm.^{3}, the total mass being $3{\cdot}1 \times 10^{-7} \times$ Sun's mass, or about one-tenth of the Earth's mass.

We might conceive of a fluctuating arrival of the supply.

For instance, consider the arrival of meteorites in an eleven-year period. Let us suppose that the swarm approaching the scorching Sun leaves a small percentage of its mass in the form of splinters, dust, and gas in the neighbourhood of the Sun, and that these remnants circulating in new orbits round the Sun for months are slowly captured by the Sun. Such a mode of supply would periodically bring matter swiftly up from outside the Earth's orbit, leave it near the Sun to be scorched, vaporised, and slowly deposited (after the sifting process exerted by light-pressure).

Here we have a fluctuating supply coming to a region of preparation. It arrives perhaps from only one or two special quarters, but by scorching treatment it is spread around the Sun before slow deposition begins. Here we seem to glimpse another mechanism. If this deposition produces an upset of circulation of the solar surface, we may fairly expect it to be rapid in its action on first beginning, and less and less active as the supply is gradually exhausted. May we then utilise our accumulated knowledge about the rapid rise and gradual decline of sun-spot activity and about the rapid rise of coronal display and its gradual reversion to the form of equatorial extension—may we use our knowledge of these changes to justify the search for some plausible form of fluctuating supply, which will not upset the rest of the solar system?

Such a supply would from that point of view be peculiarly evasive. You will remember how Professor Newcomb, in considering possible hypotheses for the explanation of secular variations, was only just not ready to postulate an undiscovered planet or ring, whose mass was inversely proportional to the square of its distance from the Sun, with a value equal to $\frac{1}{160}$ that of the Sun, if it were at the Sun's surface. It seems, therefore, as if we might crowd a large mass into what I have called the region of preparation. If the dynamical astronomer will allow this, then the astrophysicist must himself develope or must call upon the mathematical physicist to develope the theme through the intricacies of a kinetic theory of gases at pressures of the order of 10^{-12} atmospheres in which the free path must be of the order of 140 kilometres, and the molecules are moving with planetary velocities.

For the moment, I think the astrophysicist will have his hands full in co-ordinating the observed phenomena. Hale's splendid work on Mount Wilson is enormously hastening this work of co-ordination. But we want more workers and more co-operation, not only in observing, but in thinking about the observations.

Perhaps I may be allowed to summarise these remarks with the words I have used in a review of Professor Hale's book on Stellar Evolution, which will appear, I hope, in the next number of the *Astrophysical Journal* (1909 March).

We have suns with incandescent photospheres maintained by convection currents which carry the energy from within the sun to the radiating photosphere. Such suns, by their gravitationally attracting power, are constantly drawing matter in upon their surface. But their radiation exerts by the agency of light-pressure a selective action on matter so attracted. We may divide* the attracted matter into three categories—(i.) molar matter, in masses large enough to be drawn in in spite of light pressure, having diameters longer than about $2\frac{1}{2}$ times the wave-length of light; (ii.) molecular matter, in masses small enough to escape, in virtue of diffractional effects, the repulsion of light, having diameters less than about one-tenth of the wave-length of light; and (iii.) light-driven matter, in masses intermediate between molar matter and molecular matter, and subject to the repulsion of light.

The reversing layer of the Sun is provided by molecular matter constantly streaming across what we may call a critical envelope concentric with the Sun, and probably is in a slightly modified state of radiative equilibrium. The constant flux of matter here involved is provided by those constituents of the planetary whirl of molecular matter circulating round the Sun, which are directed inwards upon the Sun in virtue of properly directed collisions. This constant flux appears to me to be of the essence in the suggested aspect.

The molar matter may be active in producing local disturbances which result in sun-spots and prominences.

The light-driven matter is probably intimately connected with the apparent repulsion of comets' tails.

The corona is formed and maintained by the joint action of molecular matter and light-driven matter, the former probably being involved in the arches, and the latter being responsible for most of the long-drawn streamers.

Under the influence of local disturbances, regions of the Sun may emit corpuscles which succeed in penetrating the lower strata of the reversing layer, and cause higher strata to glow as if their effective temperature were higher than lower strata, and thus bright flocculi arise.

The difference between stars of first and second type might be referred partly to the difference in the relation between the critical envelope and the photosphere, as conditioned by the mass and density of the nucleus within the photosphere, and partly to the inability of solar stars to retain hydrogen and helium (Schuster, *Astroph. Jour.*, xvii.).

The peculiar features of stellar spectra of third and fourth types might be viewed as the result of the accidental nature of the molecular matter circulating round them. The third type stars

* Schwarzschild, Sitzber. München, 1903, Heft iii.

would require titanium meteorites, whilst those of fourth type would be fed by comets.

The most difficult part of the whole matter seems to lie in accounting for the organised rotation of the vapour which we observe in the spectroscopic determination of the solar rotation. The difficulty lies in the reconciliation of the high planetary velocities that must exist in the whirl of gas with the low value of the observed velocity on the Sun's equator. It would seem certain that the survival of narrow Fraunhofer lines must be a residual phenomenon.

If the Sun's mass were to increase by 4×10^9 grammes per second for a million years, the period of the Earth in its orbit (the length of the year) would be diminished by $\frac{1}{1000}$th of a second. Such an increase of mass would be brought about by a continuous stream of matter over the whole surface of the Sun at the rate of about $6{\cdot}6 \times 10^{-14}$ grammes per second per square centimetre; that is, by 30 particles (each of diameter $\lambda/10$ and sp. gr. 5·5) per second per square centimetre, or by gas of the molecular weight of air streaming in with an effective radial velocity of 1 cm./sec. at pressure $75 \times 10^{-12} \times$ atmospheric pressure, or by 3000×10^6 molecules of air per second per square centimetre.

I have tried, in setting this aspect forth, to steer a course between the unintelligible by reason of brevity and the unendurable by reason of length, and the statement of the case must needs suffer. But it would seem well to submit it for what it is worth to the tender mercies of workers who may be ready to co-operate in developing the best sides of it and eliminating the bad.

The Meeting then proceeded to the election of the Officers and Council for the ensuing year, when the following Fellows were elected:—

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Sir David Gill, K.C.B., LL.D., Sc.D., D.Sc., F.R.S.

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H. F. Newall, Esq., M.A., F.R.S.
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